In the vicinity of Sterling, in Whiteside county, there are two considerable quarries in this formation which are especially notable. The rock is here a very compact, hard stone, and one quarry has been worked to a depth of about 30 feet. The upper beds are quite thin and can be taken out in very large slabs, which make very excellent flag-stones. The lower beds are of moderate thickness with a compact, argillaceous limestone, furnishing an excellent building material, and have been quite largely quarried. Samples of this stone were tested by the United States authorities at Rock Island, and showed a strength to resist crushing varying from 7,000 to 10,000 pounds per square inch; in specimens 2 inches square and 4 inches high, a strength nearly equal to that of similar specimens from the Joliet and Lemont quarries. That this quality of stone has a very limited extent, however, in these beds the small quarries and other exposures within a limit of 2 miles show very conclusively. In Hopkins township, east of Sterling, is another similar quarry, where almost, if not quite, as good stone has been quarried considerably. A much less thickness of the strata furnishing good building stone is exposed here. In these quarry stones the addition of a considerable percentage of the carbonates of lime and magnesia has made the shales impure magnesian limestones and given them locally strength, durability, and reliability. At all other points where they are quarried, however, though they may in places appear to yield durable stone, they are liable to furnish occasional stones which, upon exposure, will rapidly disintegrate, and they are extremely unlikely to furnish anywhere any stone which will have more than a small local value, or be the basis of any regular industry.

NIAGARA GROUP.—The limestones of the Niagara group show in no place a thickness of more than about 100 feet, but are the surface stone over a very large area in the extreme northeastern, northwestern, and western part of the state. Nearly everywhere when exposed they furnish at least a good ordinary building stone, while in very many localities the stone quarried from them is of unusual excellence and applicable to almost all of the uses for which stone is required for building purposes. Their principal area of occurrence, in point of territory covered, lies in the extreme northeastern part of the state, where they extend from the northern boundary along the lake shore, and as far south as the central part of Iroquois county, in a band whose varying width averages about 40 miles.

In Jo Daviess, Carroll, Whiteside, and Rock Island counties are two very irregular areas of considerable extent. Farther south, in Pike county, and in Calhoun and Jersey counties, are two small areas, the latter of considerable importance, while in Alexander county, at almost the extreme southern point of the state, they occur again in a narrow area extending two-thirds the length of the county from near its northern boundary along or closely adjoining the Mississippi river.

In the first-mentioned area they are almost everywhere quite deeply covered with deposits of bowlder drift and clays, except where rivers or streams of some considerable magnitude have cut through these coverings. This is especially true of the extreme northeastern counties, McHenry and Lake, where the covering is very deep, and where those exposures which do occur or have been made show the rock to be too flinty and thinly-bedded to be of any value. To the southward, especially as they approach the southwestern limit of the area, the main valleys of the Fox and Illinois rivers show numerous exposures of the rock, most of which are capable of furnishing an excellent building material. The most important of these are found extending along the Illinois river from 2 miles above Lemont to a few miles below Joliet in an almost continuous line. The exposures of value for building stone are almost entirely confined to the left or south side of the valley, except at and below Joliet.

At Lemont the stone quarries lie on both sides of the Illinois and Lake Michigan canal, which here skirts along the valley above the base of the hills on the left bank of the river, though principally on the southwest. The beds are quarried to their lower limits through a variable thickness of from 12 to 40 feet. The stone here is uniformly a very fine grained, homogeneous, light drab limestone, occurring in beds from 6 to 24 and some times 30 inches in thickness. The beds are divided vertically by seams occurring at somewhat irregular intervals of from 12 to 50 feet, and continue with quite smooth faces for long distances, and also by a second set running nearly at right angles with the first, but only continuous between main joints and occurring at very irregular intervals. This structure renders the rock very easily quarried and obtainable in blocks of almost any required lateral dimensions.

The stone is easily worked into required shapes and takes a fine, smooth finish, which can hardly be called a polish. At the works of the Singer & Talcott Company large quantities of the stone are planed by machines closely resembling those used in planing surfaces of iron. This forms a very rapid and cheap method of finishing flagging stones and preparing stones which are to receive a smooth finish for the polishing-bed. Very large quantities of flagging stone are gotten out by this company, which for the past few years has supplied nearly, if not quite, nine-tenths of the stone for that purpose put down in Chicago, as well as large quantities for other places. The finer and more homogeneous varieties can also be very readily shaped into any of the forms which lathes are capable of turning out, such as balustrade work, and a great deal of this sort of ornamental stone-work is made here. The stone can also be readily carved in bas-relief, but is not sufficiently tough for high relief work. Its color is a bluish-gray to nearly white, and that quarried in this immediate vicinity seems to contain less iron oxide than that quarried lower down, at and below Joliet, and does not tarnish so much.

Quarrying has hitherto been largely done under very light stripping, but most of the future developments of these quarries must necessarily be done under very heavy stripping of clay and medium-sized gravel. This is here all done by hand. The stone here is injured by exposure to the frost while containing its natural moisture. This is a cause of either a considerable annual expense in making earth protection, or annual loss in destruction of stone, except in a few of the quarries so fortunately situated that they can be flooded during the winter season.

The principal market for the stone quarried here is the city of Chicago, but large quantities of the stone are also shipped in every direction to points throughout northern Illinois and the adjoining states of Michigan, Indiana, Iowa, and Wisconsin. These quarries extend for nearly 4 miles below Lemont, where a gap occurs, to just below Lockport, from which point a line of closely-adjoining quarries extends to below Joliet. The finer varieties of this stone do not seem well fitted for heavy masonry in damp situations. Fine clay seams abound, which are invisible when the stone is first quarried, and when it is used under ordinary circumstances generally do not develop at all, but in such situations as expose the stone to heavy moving loads, or to alternate moisture and dryness accompanied by frost, they are soon developed and often render the stone worthless. Even the purest and best of the stone, especially in cities where much soft coal is burned, becomes somewhat tarnished to a light yellowish tint after long exposure, but does not become of a strong buff color.

The quarries of the Joliet group extend from about a mile below the village of Lockport to about the same distance below Joliet. The total thickness of Niagara strata exposed here is apparently much greater than at Lemont, and two fairly distinguishable varieties of the stone are quarried. That quarried at the lower beds, in the vicinity of the penitentiary, on the right bank of the river, and just below the city closely adjoining the river, is generally a rougher, more irregularly-textured stone, occurring in beds as much as 24 inches thick, and is now chiefly used for ordinary and heavy masonry, and very little for ornamental purposes. This stone, upon exposure, becomes tarnished to a very decided and sometimes a quite deep buff tint, which is not a handsome color for face or ornamental stone. It appears, however, to be especially well suited to the purposes mentioned above.

In the quarries back from the river, at higher levels, the stone is generally a fine-grained, much more homogeneous rock, much of it quite equal in this respect to the best of that quarried at Lemont, and it occurs near the bottom of the quarries, as now worked, in beds often from 3 to 4 feet in thickness, and is obtainable in large blocks. Most of it appears to weather-stain rather more than the Lemont stone, but to be otherwise exactly like it. It is very largely used as a building and an ornamental stone, and large quantities of it are shipped by rail to points throughout northern and central Illinois, and to every one of the adjoining states. The value of the stone quarried at these two localities is probably fully equal to that of all the other stone quarried in the state.

Along the Fox River valley, from Elgin to Aurora, there are occasional exposures of the Niagara limestone, some of which are considerably quarried. In all of them, however, there is a heavy covering of drift, which renders the quarrying quite expensive.

At Batavia there are extensive quarries. The drift covering necessary to be removed is from 20 to 40 feet deep, almost entirely sand and medium-sized gravel. There are three large quarries on each side of the river whose products are all entirely similar. The stone is rather rougher, coarser, and more irregular in texture than that at Joliet and Lemont, and is more compact and difficult to work. A few of the beds furnish stone fit for ornamental work in fairly large sizes. The expense of quarrying has been very greatly increased by the heavier stripping required.

At Aurora there is also a very large quarry of the same excellent and durable stone, the product of which is mainly used for rough foundation and heavy masonry.

There are also quarries of some value at Thornton, on the Illinois Central railroad, and at Blue Island, on the Chicago, Rock Island, and Pacific railroad. There is also within the city limits of Chicago a quarry in the limestone of this formation, which is there impregnated with organic matter that gives the stone a dark and dingy tint upon exposure, and soon imparts to it an appearance of great age. It was used in the construction of one of the principal church buildings in the city, but it was most largely quarried for lime and ordinary wall stone.

At Kankakee, Kankakee county, there are two large quarries. The stone quarried there is a compact, coarse, somewhat irregularly-textured dolomitic limestone containing rather numerous small cavities and sand-pits, but it is a strong and durable building material, especially valuable for resisting and enduring under very unfavorable circumstances when exposed to dampness and frost, and has very considerable strength. It has been largely used as face-stone in building work, but contains numerous crystals of pyrites which decompose and stain the stone dark yellow in patches, badly marring its appearance. Large quantities of the stone are used in bridge work along the lines of railroad passing through this place.

In the area of Niagara limestone lying in the northwestern part of the state, in Whiteside and Jo Daviess counties, are numerous exposures, and the beds furnish everywhere a rough-textured, heavily-bedded, durable stone, excellent for all kinds of ordinary heavy masonry, but they are nowhere extensively quarried. Farther south, in northern Rock Island county, these beds, when found, are softer and excellent for lime-burning, but furnish no first-rate building material.

In Pike county the Niagara rocks form the base of the Mississippi River bluffs for a considerable distance. They are here of somewhat rough-textured, compact, buff-colored limestone of great durability, a building material for ordinary and heavy masonry quite equal to the best Joliet or Grafton stone. The same stone is also found high up on the river bluffs in southern Calhoun county, and also all along the Illinois and Mississippi River fronts of Jersey county to just below Grafton, and everywhere presents precisely the same physical characteristics.

At Grafton the stone is very extensively quarried, principally for the Saint Louis market, but considerable quantities of it are also shipped to other river points, the river having been, to the present time, the only channel for transportation available. The stone quarried here is of very great strength and durability.

The rocks of this group also occur in the river bluffs of Union and Alexander counties, in the extreme southern part of the state. Like the Trenton beds which they overlie, they are there mottled, semi-crystalline rocks, occurring in very heavy beds, the stone taking a fine polish and capable of yielding a very handsome ornamental stone, as well as a thoroughly reliable and handsome building material. They are not, as far as I could learn, yet worked.

DEVONIAN.

The Devonian age is represented in Illinois by a series of shales and limestone, of small total thickness, varying from 10 to over 100 feet. The exposures of these rocks are not numerous and are of very limited extent. In Calhoun county they include about 10 feet of a coarse, gray limestone, useful and slightly used as a building material. In Jackson, Union, and Alexander counties some of the beds might be utilized for the same purpose.

In Jackson county there are beds in the Devonian series at Bald Hill and at Back Bone which are very hard and even-textured and take a fine polish. They are of variegated color also, and have been worked to some extent. Other beds in the same series also furnish excellent rough building material.

CARBONIFEROUS.

The rocks of the Carboniferous age underlie the greater part of Illinois. They form a series of very great thickness in their greatest development, probably over 2,500 feet, and are of very great importance not only because of the mineral wealth, especially of coal, but also because of the vast, almost unlimited, quantities of most excellent building stone they are capable of supplying, and very cheaply, at great numbers of points over the state. This is especially and particularly true of the lower division of the group, the sub-Carboniferous limestone, so called, which furnishes a maximum thickness of limestones, sandstones, and shales; principally limestones of over 1,500 feet, in the southern part of the state, which gradually thins out to less than 1,000 feet total average, toward the northern limit of their exposure. A very large proportion of these beds furnish excellent building stones wherever found.

The most northerly exposures of these beds occur in southern Mercer county, and from here they extend southward in an area of very variable width from 5 to 30 miles or more, always along or close to the Mississippi river, and nearly the whole length of the state to southern Jackson county, where they swing to the eastward and cross the state, through Union, Johnson, and Pope counties to Hardin county, at whose easternmost limit they cross the Ohio river into Kentucky. They form the whole or the greater part of the Mississippi River bluffs throughout the entire distance from Mercer to Jackson county, with the exception of the limited localities already described, where the river front is occupied by older rocks. Five main subdivisions of the rocks of this group were made by the Illinois geologists and traced throughout most of the area.

KINDERHOOK GROUP.—The Kinderhook group, the lowest and least important of the series, has at its greatest development a thickness of less than 200 feet, which in places includes limestone strata of no great thickness available for building stone, but which are not always a reliable material, and nowhere extensively quarried.

BURLINGTON LIMESTONE.—The Burlington limestone, next in the series, occurs in beds whose variable thickness amounts in many places to over 200 feet; it is a very pure carbonate of lime, highly fossiliferous, and for almost its total thickness is an excellent building material.

In Henderson county it outcrops along the river bluffs through the whole length of the county. It is a fairly even textured light blue or yellowish-gray, moderately thick-bedded stone, but little affected by weather. The beds have been quite largely worked in the eastern part of the county, and also at Sagetown, where a very extensive quarry furnishes a large quantity of material, principally used in railroad constructions. The stone for the piers of the Mississippi River bridge at Burlington was taken from this quarry and has stood the exposure and abrasion with great success, and seems also to have been discolored little or none.

It forms no part of the surface of Hancock county, but in Adams county is again exposed along the whole line of river bluffs, from Quincy to the southern line of the county, having everywhere about 40 feet in thickness of moderately heavy beds of excellent but rather rough-textured building stone. At Quincy, within the city, a thickness of about 100 feet of this limestone is quarried, and is most of it available for building stone; an excellent and durable material, but not a fine ornamental stone. Some few of the layers contain pyrites and become badly discolored upon exposure.

Throughout the whole river front of Pike county, both on the west and on the east, these beds form a continuous outcrop, including, as in Adams county, about 40 feet in thickness of beds available as building material. The stone is here often found in beds from 2 to 4 feet thick, and is, wherever free from flints, an excellent building and dimension stone. Numerous exposures are also found along the creeks in the northern part of the county.

In the vicinity of Jersey landing, Jersey county, it forms the entire river bluff, and is a nearly white, somewhat uneven-textured, medium-bedded limestone, containing occasional seams and flints, and furnishing a very good building stone for rubble and ordinary cut-stone masonry. It is very little quarried now.

KEOKUK GROUP.—The Keokuk group, next in succession, consists chiefly of limestones. Its rocks extend in Illinois from central Henderson county along nearly the whole band of sub-Carboniferous rocks to Hardin county. Only the middle beds of this formation furnish good building material, and in these there are a number of noteworthy quarries. Their extreme thickness is about 70 feet, and the rock is an even-textured, light gray colored,

easily-dressed stone, which does not discolor or show any signs of disintegrating upon exposure. In most places its beds are separated by clay seams sometimes of several inches thickness, the beds themselves varying from 6 inches to 3 feet.

In eastern Henderson county these beds are exposed in numerous places, especially in the vicinity of Biggsville, and there furnish only an ordinary building stone in blocks of very moderate dimensions.

In Hancock county these beds form the base of the river bluffs for a long distance, and have been extensively quarried in a number of places. Near Nauvoo large quarries were at one time worked, and furnished the material of the once famous Mormon temple at that place. Stone from these quarries was used also in the construction of the United States court-house and post-office buildings at Galena and at Dubuque. South of here about 4 miles the Tallant Stone and Marble Company has opened a considerable quarry in the same beds, and furnishes a rather coarse, uniform-textured, white, and very light gray limestone, which is easily cut, sawed, and shaped, and does not tarnish upon exposure. Some of the beds furnish stone which can be polished, and in places some of the beds contain much cherty material, while others are entirely free from it. Very large blocks are easily obtained. The same beds have also been much quarried at Hamilton and Niota in the same county.

The analysis of this stone (*Illinois Geological Report*, Vol. I, p. 99), specimen from Nauvoo quarry, gives:

	Per cent.
Carbonate of lime	82.48
Alumina and iron	2.10
Insoluble matters	12.50
Water and loss	2.92
Total	100.00

Throughout Adams county where these beds are found they furnish, when free from flints, a stone precisely similar to that at Nauvoo. They outcrop in very many places throughout the northern and northeastern part of the county.

In Pike county the beds of this group, which rest directly upon the Burlington beds, furnish an excellent building material very like that of those beds. They outcrop, especially in the vicinity of Griggsville, where the beds are unusually free from flints. In Jersey county, though there are numerous exposures, they furnish no excellent building material on account of the number of flints they carry. In Hardin county a heavily-bedded limestone, in layers from 1 foot to 3 feet thick, outcrops along the Ohio River bluffs, but is not quarried for building material.

SAINT LOUIS GROUP.—The beds of the Saint Louis group furnish a very large amount of building stones of considerable variety in texture and properties. In Hancock county the lowest beds of the series are of a somewhat arenaceous magnesian limestone, generally of a light yellow or buff color, darkening upon exposure. The stone cuts readily and can be obtained in quite large blocks, and possesses very great durability in the most trying situations. Large quarries in these beds were opened and extensively worked just at the head of the Keokuk rapids, on the Illinois side, and furnished nearly all of the riprap for lining the government canal around those rapids, beside considerable of the cut stone used in the locks, where it has resisted very successfully. These quarries have been abandoned for several years, however. This stone readily breaks into blocks for the better class of rubble, very square and of convenient sizes.

Below Warsaw these beds attain a very great thickness, and are quarried considerably in a good many localities. They nearly everywhere contain minute crystals of pyrites, which decompose upon exposure and discolor the stone. There are also numerous exposures upon the creeks in the eastern part of the county. These same beds are also found in the northern and northwestern part of Adams county, where the rock is of the same character. In Pike county they are only found in the extreme northern and northeastern part, and where occurring furnish the same brown magnesian limestone, a most excellent and durable building material.

In Calhoun county they form a continuous exposure along the river bluffs, and are everywhere a rather thinly-bedded and hard but very durable building rock, and would furnish an almost inexhaustible supply.

In Jersey county the principal exposures occur along the Piasa; and on the Mississippi river, just south of the Piasa, at its mouth, in Madison county, are also large exposures. The beds here are nearly true dolomites, are often found with very heavy layers, and furnish a very excellent heavy wall stone. Some of the upper beds at this last locality take a fine polish, and could be used as an ornamental stone; they also furnish excellent flags.

The bluffs at Alton present a thickness of over a hundred feet of these beds, the whole of which is quarried for lime and building stone. The middle and lower beds furnish some excellent hard, even, close-textured rock, in every respect good building material. The brecciated beds found here have been largely used for rough, heavy masonry, but observation shows them unreliable for that purpose, gradually becoming separated into irregular fragments.

In Saint Clair county a total thickness of about 200 feet of these beds is exposed, nearly all of good building material and available. Some of the thinner beds furnish an excellent flagging, while the heavier beds contain a light gray, compact stone, excellent for every variety of mason work. They form the river bluffs through most of the southern part of the county. In Madison county the beds exposed are also dolomitic to some extent; at places pure

dolomites (specimens analyzed at the Smithsonian Institution, Washington, proved to be calcareous dolomites). They furnish everywhere an excellent material for building purposes. Occasionally the stone is sufficiently hard and compact to take a fine polish.

In Monroe county the rocks of this formation are pretty well distributed over nearly the whole of the county. They are extensively quarried at Columbia and at Waterloo. In the vicinity of the latter place the rocks quarried are especially suitable for cut-stone work of every variety. They are of a bluish-gray color, sometimes nearly white.

In the vicinity of Columbia there is exposed in the lower division of these beds about 20 feet in thickness of heavily-bedded, light gray, granular limestone entirely free from flints, splitting easily and furnishing blocks of any required size. There are also in the lower division of these beds heavily-bedded buff limestones which make most excellent heavy wall-stone. These are exposed in about 100 feet thickness at and in the vicinity of Salt Lick point, on the Mississippi river.

In Randolph county they also occur in the northwestern part of the county 200 feet thick and in beds similar to those in Monroe county.

In Jackson county these beds furnish some good building material.

In Union county, in the vicinity of Jonesboro', are numerous quarries, not now much worked, of massive, granular, nearly white limestone, an excellent building stone for ordinary situations; they are of fine appearance and obtainable in large blocks, but are said not to resist when exposed to frost in damp places.

In Johnson and Pope counties also these beds would furnish excellent building material in large quantities, but they are nowhere worked. At Roseclair, in Hardin county, large quarries were worked for many years in the beds of this formation, and are yet worked, though not on so large a scale.

Oolitic beds occur in the bluffs just below the village, and are somewhat quarried. They furnish a very hard, fine stone which takes a high polish, has a dark bluish-gray color, and is a very durable and handsome stone. Large blocks are readily obtainable. Places for several large quarries conveniently located on the river can readily be found here.

CHESTER GROUP.—The beds of the Chester group expose a thickness in places of over 600 feet of alternating limestones, sandstones, and shales, capable of furnishing large quantities of fine building material. One of the sandstone beds of this group is found capping the bluffs at Alton, where it is a clear, white, pure siliceous sandstone, fine-grained, perfectly homogeneous, and occurring in massive beds from which very large stones might be obtained. It shows no tendency to discolor upon exposure. It is little quarried, and not at all for ornamental purposes, for which it appears very suitable.

In Saint Clair county the lower sandstone of the group furnishes a durable stone, buff or brown in color, easily quarried and cut, hardening upon exposure, and obtainable in blocks of any required size possible to be handled. Overlying this is a thinly-bedded limestone of the same group available for common wall masonry.

In Monroe county the lowest sandstone of the group shows in a thickness of 60 or 75 feet, generally evenly-bedded and uniform-textured, but occasionally concretionary. This outcrops in numerous places in the southeastern part of the county. Some of the limestones of the group outcrop here also, and furnish good rough building stone.

In Randolph county, where this series finds its greatest development, the lower limestone of the series is 150 feet thick. It is all fit for ordinary building stone, while some of the beds also furnish excellent dimension stone for cut work. Some of the upper limestone beds of the series also furnish excellent material for cut-stone work.

The Penitentiary quarry at Chester is worked in these beds, and much riprap, rough building material, great quantities of paving blocks, and considerable cut stone of fine appearance are obtained.

The lower sandstone of the group is here precisely similar in characteristics to the same beds in Monroe county, but is here more than 100 feet in thickness. It has been somewhat quarried just above Chester, where it can be made to furnish blocks of great size. It is a stone of great strength and durability, and presents a uniform and good appearance, its color, however, being somewhat against it.

The other sandstones of the Chester series furnish a fine-grained, soft, even-textured, buff and brownish colored stone which cuts with great ease when first quarried, but hardens upon exposure and changes color very slightly. It is a rather handsome building material. The southern Illinois penitentiary is built largely of these sandstones, and presents a fine appearance.

In Jackson county, where they occur, the limestones of this group are generally too siliceous and too hard to work, and usually furnish stone only for ordinary building purposes. The sandstones, however, can furnish large quantities of excellent building material. They are soft, fine-grained, harden on exposure, are durable, and usually of dark brown or strong yellow color.

In Union county, when not too argillaceous, the limestones furnish good building material. At Cobden there is a very heavily-bedded, compact, dark blue, very hard limestone, very difficult to cut, but which would make a most excellent bridge and culvert material, and has been somewhat used for that purpose.

In Johnson county the sandstones of this group occur in easily workable position in numerous places, and would furnish excellent flagging and dimension stone. Some good building material is also obtainable from the limestones.

In Pope county, while some few of the sandstone exposures furnish a fine building material, most of the outcrops show the stone to be too hard and uneven. Where exposed near the Ohio river the limestones of this group furnish excellent building stone for the finer classes of work.

In Hardin county some of the sandstones are very refractory and are used for furnace linings. They furnish also some good flagging and some fair building material.

The Coal Measures underlie the greater part of Illinois, probably three-fourths of its territory; the greater portion of the territory is deeply covered with the more recent clay deposits, and exposures are rather scarce. In the southern part of the area there is, however, a less depth of these deposits, and more numerous exposures, many of which furnish building material of some sort. Their rocks comprise here, as elsewhere, alternate beds of sandstones, shales, limestones, and conglomerates. Most of the sandstones are coarse and irregular in texture, and generally disintegrate upon exposure. In the southern part of the state there are, however, many places where they are hard, fine, and tolerably durable, and in many localities furnish excellent flagging and good building material. The limestones of the series are generally rough-textured, thin-bedded, and shaly, and in but few places furnish a material fit for ordinary use. In comparison with the sub-Carboniferous beds, these, however, will furnish but a small total amount of really excellent material.

The points where beds in this formation have been worked are few in number and of little importance generally.

Between Cobden and Mahanda, on the line of the Illinois Central railroad, and adjoining the track, is a small quarry in a medium-bedded limestone, which might be very greatly enlarged. The beds are regular and even, and the stone appears to be quite durable.

Three miles south of Carbondale, on both sides of the little creek through whose valley the railroad runs, are exposures of a reddish sandstone of considerable value for building material. It is a medium-grained, even-textured stone, fresh fracture, dark red, weathering to a purplish-gray tint, easily quarried, but becoming quite hard upon exposure. At the top of the eastern bluff a large quarry was once worked but is now abandoned. The convenient outcrop could supply a great quantity of the material. The bed seems to be about 14 feet thick, and would easily furnish sawed stone 4 by 10 by 40 feet in one piece. The stone for the State Normal School building, a very handsome structure, was obtained at this quarry. On the west side, opposite, are excellent exposures of the same rock, forming a similar ledge low down on the bluff. The beds lying above this ledge are thin and hard, and furnish a fair flagging, which is quarried in moderate quantities at this place.

At Xenia, Clay county, there is a small thickness of drab-colored, fine-grained, even-textured sandstone exposed in a creek valley for 2 or 3 miles, furnishing a fair building and ornamental stone, and is quarried and shipped in moderate quantities. There are also said to be sandstone exposures along Crooked creek, in the same county, of considerable value for building purposes.

At Carlyle, Clinton county, are small quarries in a rough-textured, durable limestone; and on Shoal creek, a few miles west of Carlyle, limestone strata of fair quality for both ordinary and cut-stone work are found outcropping in a number of places, and are quarried in a small way.

In Greene county are beds of sandstone which would furnish considerable quantities of fair building stone, and there are numerous other exposures of like character. In no place, however, are there any beds which are likely to prove of more than local importance.

In the northern part of this area the covering of the rock formations is so deep and the country so level that large districts are without rock exposures, and depend entirely for their supply upon the means of transportation. The county, however, is crossed in every direction by railroads. While the resources of the state within herself are sufficient many times over, it is quite likely that much of the building stone for the state, especially in some portions of it, will be brought from Ohio and Indiana, because of its great excellence and proximity to the market.

Nearly all the northern, western, and southern counties have ordinary building stone in great abundance and well distributed.

Increased facilities for transportation have been rapidly extended throughout many of the counties richest in this particular commodity, which have hitherto had no railroads, and this must undoubtedly result in the development of considerable industries in quarrying and shipping of these materials to the less favored districts.

I have to acknowledge my great obligation to the Illinois geological reports for facts about much of the territory having no present quarrying industries, which could not be visited, and for other facts gleaned from that report and incorporated herein.

MICHIGAN.

By Professor Allan D. Conover, *Special Agent.*

The state of Michigan contains rocks representing a larger range of geological formations than those of any of the adjoining states, but within her limits their lithological character and mode of occurrence, as also those of the later and looser deposits, are such that there are comparatively few points where the quarrying of stone for building purposes is ever likely to become an important industry, but at some of these it is of very considerable importance.

The Archæan rocks occur only in the northern and northwestern parts of the northern peninsula, and have not as yet furnished any building stone. The Huronian subdivision, however, carries beds of very considerable thickness of slates of very great value as roofing material. These have unusual development in the vicinity of Huron bay, on the coast of lake Superior, and were during the last decade opened and worked at a number of points, all in the same vicinity, in township 51, range 31. Several stock companies were formed, with large capital, each owning large tracts of land in this township, and some work was done in developing quarries, but the difficulties of transportation and shipment and small market for their product led to their temporary abandonment and the failure of the companies owning them. These beds furnish slate very readily cleavable, generally of black color, but also occurring in places of green, purple, and gray colors, in vast quantities, and so far as their exposures and the limited trial given them go to show, of very considerable enduring power, and they bid fair to be of very considerable value as the development of this and the adjoining states creates more market for material of the kind. Besides these deposits I do not know that these rocks furnish any material now used in building, or any whose character, so far as known, renders them likely to be quarried for that purpose even to supply local demand.

Beds of limestone, altered to marble, occur associated with the granitic rocks of the Laurentian, which furnish very numerous handsome specimens, but do not, I believe, occur anywhere, as yet discovered, where large blocks of material of homogeneous character can be obtained in quantity. It is quite possible that the granitic beds may some time furnish valuable building material of that class, and also that the quartzites which occur in large quantities and are easily reached may also furnish valuable paving material where the location of outcrops of the suitable quality occurs conveniently to cheap transportation facilities; but as yet nothing of that sort has been developed.

The Potsdam sandstone is likely to furnish the largest quantity and the best of the building material found within the state. Its occurrence is mainly in the northern part of the Upper Peninsula, where very numerous exposures occur, especially along the lake shore. The lower beds of this formation furnish a rather coarse grained, homogeneous, siliceous sandstone, rather soft when first quarried, and easily hewn, but hardening on exposure. Its color is generally reddish, or some shade of reddish-brown, and, when uniform, renders it a very handsome material for outside and ornamental work. It often occurs of mottled-white or yellowish-white and red-brown colors. These parts of the stone are usually rejected, though some buildings have been built of them at Marquette and also in Chicago, and present a rather handsome, picturesque appearance. They seem to be equally durable with the rest. The stone usually occurs in approximately horizontal but usually very uneven beds, and is always readily obtainable in large masses. In most places where quarried the stone carries occasional, sometimes numerous, pockets of clay of very various sizes, which considerably affect its value by causing much waste and rendering the stone unreliable. Where free from these, however, the stone is a durable and reliable one, and always commands a high price and a considerable market in all the large lake cities.

It was, during 1880, only quarried regularly at one quarry, which is within the city of Marquette. Numerous attempts to quarry elsewhere have usually failed, principally from the difficulty of obtaining a safe harbor at the quarry spot. This difficulty is very likely, however, to be overcome, so that quarries will be opened in numerous places. These beds occur especially in the vicinity of Marquette, in many places along the lake shore, west of Keweenaw point, and also near the eastern end of the coast of lake Superior along the lower valley of the Laughing Whitefish river and the country around it. In this latter locality the stone is very hard, compact, reddish, or speckled, is heavily-bedded, readily splits to required thicknesses, and is especially suitable for heavy masonry, but, because of its hardness, not well suited for an ornamental building stone. It is found underlying a very large territory and is easily obtainable almost everywhere.

The Calciferous group occurs in the Upper Peninsula only where it extends in a very narrow band from a point some distance northwest of Menominee, northeastward, swinging to the east, to the extreme eastern end of the peninsula. It exposes an extreme thickness of about 100 feet of calcareous sand-rock of very variable character, the more calcareous beds of which sometimes furnish good building material in rather thin beds and blocks of moderate size. They are, however, nowhere regularly worked as yet, the country they underlie being still entirely a wilderness.

The Trenton group is represented on the Upper Peninsula by beds of perhaps 100 feet greatest thickness of thinly-bedded shaly limestones, which have nowhere been discovered of such character as to furnish a first-rate building material. At places it is thick enough and sufficiently even bedded to quarry out in good shape, is of compact or crystalline structure, but everywhere yet worked contains too many irregular argillaceous seams to render it a safe and reliable building material. It also extends in a narrow band from west to east, through nearly the whole extent of the peninsula, just south of and adjacent to the band of Calciferous rocks. It is crossed by all of the important streams flowing into lake Michigan, and, in most cases, forms upon them falls or rapids of considerable extent, so that exposures are very numerous. To the southward lie the Niagara beds, in a similar but wider band, which covers most of the southern part of the Upper Peninsula, extending from Big Bay de Noguette eastward to the limit of the state. They furnish usually a hard, compact limestone, often in very heavy beds, but generally containing so many seams of argillaceous material as to render them liable to split and crack under the

action of frost. Some of the beds are free from these seams. Most of the region where these beds occur is a wilderness, and the beds are, moreover, heavily covered with drift, except where the streams have cut their way through. A few quarries have been opened and worked to a limited extent.

The beds of the Hudson River shale, lying in a narrow band of country between the last-mentioned formation, are everywhere too soft and too easily affected by weather to be of value as a source of building material, and can never be expected to supply material fit even for ordinary purposes.

The Helderberg group furnishes limestones of considerable hardness in places, but everywhere occurring in a brecciated condition which renders them unfit for building material.

In the rocks of the Onondaga Salt group there are on the Upper Peninsula some beds of fair gypsum, and quarries were formerly worked in them near Point aux Chênes, but were long ago abandoned. This completes the list of the rock formations of the Upper Peninsula.

Passing southward through the Lower Peninsula, we cross successively the beds of the later formation to the basin filled by the Coal Measures, which cover a disk-like area in the southern-central part, around which the earlier formations occur in concentric rings.

The rocks of the Helderberg group occur on the Lower Peninsula at its northern extremity and upon the adjacent islands, and everywhere furnish impure limestones of some value for lime, but so brecciated as to be entirely unfit for any building purposes, except the lightest and most ordinary cellar masonry. They occupy also a small area in the southeastern course of the Lower Peninsula, and there furnish beds of some considerable value. At Trenton, near Detroit, in Monroe county, is a very extensive quarry in these beds. They furnish a somewhat impure limestone, occurring in beds from 1 inch to 12 inches thick, from which no large stone can be obtained owing to numerous dry seams which occur throughout the mass. The heavier beds only are utilized for building material, and are close, compact, and rather fine grained, sufficiently hard to take a fair polish, but fit only for ordinary rubble work, while blocks selected with the greatest of care furnish material fairly fitted for such ornamental work as caps, sills, etc. Very little of the material, however, is utilized for such purposes.

Upon Macon creek, in the valley, are a number of small quarries in the beds of this formation which expose a total thickness of about 8 feet of beds 6 inches to 2 feet in thickness, and a much more compact, gray, crystalline limestone of considerable strength, and very free from the dry seams found in the rock at Trenton. The beds in the valley are covered only by from 2 to 6 feet of loose earth and can be very easily quarried. They furnish excellent material for all ordinary mason work and for very good-appearing cut-stone work, though somewhat difficult to hew. Some of the upper beds in this locality are also brecciated.

A sandstone bed of small thickness also occurs among the beds of this age which in places contains a considerable proportion of calcareous cement, and is a firm, compact rock obtainable in fair-sized blocks, nearly pure white, and to all appearances a fair and quite handsome building material. This bed was seen at the surface on Fritz Rath's farm, near Raisinville. There are also in the limestones a number of small quarries along the valley of Raisin river and Plum creek which furnish good building material. The most important of these are at Monroe.

There are in the southern part of the Lower Peninsula no beds representing the Hamilton period, but in the northern part they occur in great thickness and form the surface rock over a very considerable area adjoining that of the Helderberg group, and extending across the whole width of the state. They consist of alternate beds of limestones and shales, some of the former furnishing fair building material, quarries in which are worked at Alpena and vicinity. The stone obtained is very hard, compact, and durable, but is obtainable only in moderate-sized blocks. It is well suited for all ordinary plain ornamental stone-work, but has a rather dull, light drab color, rendering it not very attractive for the latter. It appears every way a durable and reliable stone. It is not obtainable anywhere in large quantities, but in numerous places supplies the local demand for common building stone. Where it outcrops along the shore of lake Michigan it can be quarried in several places and loaded directly upon barges in the lake.

The black shales, next in order in the geological series, furnish no material for construction.

The Waverly group, next succeeding, is by far the most important of the series in the Lower Peninsula, and furnishes a large proportion of the good building material obtained. The rocks of the group consist of alternate sandstones and shales; the sandstones, which furnish the building material, vary considerably in texture and composition, but furnish in many localities valuable building stone.

Along the south shore of Saginaw bay from Point aux Barques southwest there are numerous exposures of the sandstones of this group. At the point itself a thickness of about 16 feet of these strata is exposed, which would furnish excellent building material.

At Grindstone City, just southeast, are other exposures which are extensively worked for grindstones, for which they furnish excellent material. Some of the stone has been used for building purposes, but it has more value for its present use.

There are numerous exposures elsewhere, especially in Jackson and Hillsdale counties, very few of which have been much worked of late years. The increase of railroad facilities has greatly increased the use of the superior Ohio stones. The most notable quarry in the formation is that at Stony point, in Jackson county, where a

thickness of about 40 feet of fine-grained, buff-colored sandstone, very soft and easily dressed, but hardening upon exposure and retaining its color well, is quarried under very heavy clay stripping, and blocks of any required dimensions are easily obtained.

Beds of the same formation are also exposed at and near Jonesville, Hillsdale, Osseo, Moscow, Homer, and Condit station, in the same region, and on Black river, near Holland, Ottawa county, farther northwest. There are, however, no very important quarries, and at only a few of these places can really good stone be obtained.

The Carboniferous limestone at the base of the Coal Measures has a comparatively small development in this state, and nowhere furnishes building material of much importance. There are quarries in these beds at and near Bellevue, Eaton county, and north of Jackson, at the junction of Grand and Portage rivers. At these places the beds furnish pure, light-colored limestones in beds of moderate thickness, a very fair building material for ordinary uses. These beds also occur on some of the islands on the east side of Saginaw bay, and furnish an excellent building material for foundation walls.

The sandstones of the Coal Measures sometimes furnish very good building material. The most noteworthy quarry in these beds is that near Ionia, Ionia county, where a bed of dark red and mottled yellow or white and red stones occur in horizontal position in layers of moderate thickness, and furnish an easily-quarried, medium-grained, easily-cut, and hardening sandstone in blocks of considerable size, and a very handsome building material. The beds from the lower part of the quarry are of an even brown color; those near the top are mottled. This stone has been much used in the vicinity both for ornamental and heavy masonry purposes, and has proved itself well suited to all classes of building construction. A very handsome church edifice has also been built of the brownstone at Detroit. Beds of these sandstones are also found at Jackson, where they are somewhat quarried, and near Lansing, at Grand Ledge, and at Flushing, near Flint, but they are nowhere regularly worked, nor do they furnish any very desirable material.

The resources of the southern peninsula in building stone are comparatively very limited, except in such ordinary grades of the material as are necessary for house-foundation purposes, and even for that purpose stone is frequently lacking in very large districts. This is in part compensated for by the numerous railways which traverse the state, the close proximity of the numerous excellent building stones of Ohio, and the cheap lake transportation by which the resources of the Upper Peninsula can be reached.

WISCONSIN.

By Professor Allan D. Conover, *Special Agent.*

SILURIAN.

The great bed of Silurian rocks which almost completely encircles the Archæan area of northern central Wisconsin had previous to the census year furnished practically all of the building stone quarried within the state. Every one of the grand divisions of the belt furnishes in one or more localities material fit for ordinary building purposes, though stone suitable for the finer class of work is as yet quarried at but few places. Within the Silurian area, to which the more thickly-settled portions of the state pretty closely correspond, except where a very deep covering of glacial drift exists, there are but few regions where rock fit for the most ordinary building purposes cannot be obtained everywhere within a few miles, and almost every large town or city has within its limits, or near by, quarries of sufficient capacity to supply its own most pressing needs for that sort of building material; but there were previous to 1880 no localities (except at Bass island in the Lake Superior region) where building stone had been quarried in any quantity for export beyond the state, (*a*) and but few where it had been quarried for other than a local market. There are indeed but few places where the Silurian formations yield large quantities of easily-obtainable stone of such character as to be in very general demand. The Niagara group furnishes several of these places in the vicinity of Milwaukee; the Trenton group (Galena limestone), a number along the Lower Fox river and Duck creek, in Outagamie and Brown counties; the Saint Peter sandstone, a barely possible one at Red Rock, near Darlington, La Fayette county; the Lower Magnesian but one, at the Prairie du Chien quarries and in their immediate vicinity, Crawford county; and the Potsdam sandstone, in the Apostle islands, and possibly along the coast of Bayfield and Douglas counties.

Potsdam.—The main body of Potsdam sandstone in southern Wisconsin is made of a medium-grained, somewhat rounded, siliceous sand, the particles cemented together either by a fine siliceous powder of the grains themselves, or by a coating of carbonaceous or ferruginous cement. Where the first is the cementing material the stone is exceedingly friable and useless as a building material, but where the cementing material is either of the other two, the rock is generally of a compact and durable character and furnishes some excellent building stones. Sections of this formation in different parts of the state show a varying thickness, reaching as much as 700 feet in the central southern part. Of this the middle and by far the greater part is loose friable stone, much of it easily separated into sand by light blows. Exceptions to this occur in numerous places where the sandstone was deposited close

a A temporary exception to this statement occurred during a period of about two years after the Chicago fire, when such building stone was sent into Chicago from a number of quarries in southeastern Wisconsin.

to the Archæan area, as at the Stevens Point quarries, and those near Grand Rapids, at which last place the stone is a very valuable one, and is referred by Professor Irving to the middle portion of the Potsdam. Another exception of like character occurs along the quartzite ranges of the Baraboo region, where many facts go to show the probability of two separate sandstones laid down at different periods.

Wherever, along the quartzite ranges of that region, the sandstone is found resting immediately upon the quartzite it furnishes a medium-grained, compact, massive sandstone of great durability, which can be quarried in very large blocks, is of uniform texture throughout, free from flaws, and of colors from light straw and nearly white through various shades of light pink, the varying colors being due mainly to changes in the cementing material. The two large quarries in this sandstone at Ableman's have furnished a very large amount of stone for bridge and culvert purposes along the line of the Chicago and Northwestern railroad. The hardness of the stone and consequent difficulty of dressing have so far prevented its use for general building purposes. There is a large number of localities throughout the same region where this stone occurs, and it everywhere presents the same character, and has in many places been quarried to the extent of a few cords.

The upper beds of the Potsdam also furnish in the southern part of the state two layers—one of sandstone underlaid by the other, an impure dolomitic limestone—which immediately underlie the Lower Magnesian limestone, and occur everywhere just below the base of that formation wherever the latter is exposed in the half circle in which it comes to the surface. These beds have been given the name of Madison sandstone and Mendota limestone.

The Madison beds, wherever they occur, are rarely less than 35 feet thick, often more, and furnish frequently a slightly calcareous sandstone, which is generally a very good building stone, although never occurring in layers of a thickness suited for large ornamental stone. It is of various shades, from yellow to a light dull brown, and has been much quarried wherever found, because of the ease with which it can be shaped into appropriate forms. It gradually hardens and changes upon exposure to a rather dull yellowish-brown, and has been quite extensively used at Madison and in the surrounding country, and in many villages in the region where it occurs.

The Mendota limestone is equally persistent in occurrence throughout the same area, and includes a total thickness of from 20 to 45 feet in different localities. It furnishes a stone varying from nearly white through all shades of yellow to dull brown, is quite regularly bedded, occurring in layers up to 5 feet in thickness, and is more extensively quarried than the Madison sandstone, since it can also be burned for lime, of which it furnishes a very fair quality. Wherever it occurs it furnishes valuable building material, especially for heavy work.

The Potsdam sandstone of the region of lake Superior is of a character somewhat distinct from that in southern Wisconsin. Its rock where exposed in Wisconsin is composed of siliceous grains, medium to somewhat coarse, held together by a cement usually either ferruginous or argillaceous in its character, and is generally stained from yellow to deep brown by the ferruginous matter. It furnishes a very handsome building stone, and is quarried in masses of almost any required size. The chief difficulty with the stone as a fine building material arises from the fact that it contains, wherever yet quarried, numerous clay pockets which are liable to badly pit the finished surface. They are likely to be found anywhere in the stone when it is worked, and where ornamental relief work is being done the nearly-completed piece is often entirely spoiled by opening into one of these pockets, or the completed piece is badly defaced by the subsequent breaking away of a thin skin of sandstone and the dropping out of the clay. The difficulties which arise in this way can, of course, be partly overcome by having all the cutting, shaping, and finishing done at the quarries, thus saving the cost of transportation of useless pieces. This characteristic of the stone has proved a great drawback to its general use. Many exposures from which the stone could be readily quarried and shipped directly upon vessels are found on the islands of the Apostle group, and some are found along the coast of Bayfield and Douglas counties.

At Bass island (Apostle islands) a large quarry was opened in this sandstone, and was extensively worked during the first three or four years of the last decade. Quite heavy stripping of clay is required, and below this there is exposed a quarry face of 26 feet of good stone; below this the stone is inferior. In this depth there are three layers which in places unite. The joints are inclined about 60° and are spaced about 50 feet apart. Between these and within the beds the stone is uniform in texture and color, and without seams or cracks. It is of very much the same grade as the Marquette stone, but free from its vexatious variations of color. The quarry has been abandoned for several years, and was not worked during the census year.

LOWER MAGNESIAN.—The Lower Magnesian limestone forms the surface stone over a very large semicircular band everywhere skirting the wide Potsdam belt. Its beds consist largely of a quite siliceous dolomitic limestone, sometimes nearly pure, the siliceous or arenaceous material sometimes predominating. In a great many localities it furnishes a rather rough and irregularly but heavily bedded limestone, a good material for heavy masonry, and it is quarried in a large number of places, though nowhere very extensively. In a few localities a very excellent building stone has been quarried from it, usually from its lower or lowest beds. The most noteworthy of the places are the southern part of the town of Westport, Dane county, just west of Bridgeport, near Prairie du Chien, Crawford county, and at the summit of the Mississippi River bluffs, in the vicinity of La Crosse, La Crosse county, and northward to a point across the river from Winona, Minnesota. In the town of Westport, Dane county, is a number of quarries of considerable size, not much worked during the census year, which were nearly all opened for the purpose of

supplying stone for the Insane Hospital building located in that township. They were opened in the lowest beds of the Lower Magnesian, just above its beds of separation from the Potsdam. The Venhusen quarry has supplied the greater part of the stone for the hospital building, a heavily-bedded, compact, hard limestone of rather fine but slightly uneven texture, in color varying from very light straw to light buff when dressed, and having occasional small sand-pits. This stone does not discolor upon exposure, and its chisel marks remain after more than 20 years apparently as sharp and definite as when the stone was first built into the wall. This quarry is a very difficult one to work because of very heavy stripping.

O'Malley's quarry, 1½ miles northwest and not far from the horizon, furnishes a whiter, clearer stone. A considerable thickness of good rubble stone is succeeded by some heavy beds, 28 inches thick, which were quarried for the face stone of the United States court-house and post-office at Madison. This is a hard, somewhat arenaceous, white, uniform-textured stone, which an exposure of over ten years in that building has only turned to a very delicate straw color. It was somewhat hard to dress, retains its chisel marks unchanged, and shows no tendency to scale off on the dressed surface.

[The trimmings of the post-office water-table caps, sills, joints, etc., are of selected stone from one of the Joliet, Illinois, quarries, and have scaled off in large thin scales, entirely defacing the tool marks.]

This stone is by far the handsomest stone quarried in southern Wisconsin, except at Waukesha, in the vicinity of Milwaukee.

There are several smaller quarries in these beds and numerous places in the locality where quarries equally good could probably be opened. The Chicago and Northwestern railway traverses the town, and is not farther than a mile from these quarries.

At the Bridgeport quarries, near Prairie du Chien, the Lower Magnesian limestone is also quarried quite extensively in Marsden's quarry. The beds quarried cannot be many feet above the base of the formations. They have a ledge near the crest of the river bluffs, just west of the village, which is there perhaps 80 feet above the river, and dips gradually westward, coming to the level of the river valley before it opens upon the Mississippi river. Numerous quarries have been opened in this ledge and large quantities of stone removed, but all the quarries except Marsden's have been abandoned, and an examination of them indicates that probably none of them could be worked profitably, except for an unusually favorable market. One or two places remain where good quarries could probably be opened.

The stone quarried from the heavier and more regular beds is a nearly white, somewhat creamy-tinted limestone, which does not iron-stain or change much upon exposure, except to take a slightly gray dust-colored hue. It dresses rather easily, and seems to harden somewhat on exposure. It is on the whole an excellent stone for all building purposes where a very fine finish is not required. This and the adjacent quarries furnished the stone for the state capitol, and from this quarry the stone for the extension of that building, now in process of construction, is taken. Large quantities of dimension stone are also now being shipped from here to Minneapolis, Minnesota, and much stone furnished for bridge work upon the Prairie du Chien and River divisions of the Chicago, Milwaukee, and Saint Paul railway.

On the bluffs next the river valley, and near their summit, in the region around La Crosse, there outcrops and is quarried a limestone (lower beds of Lower Magnesian) the lower beds of which yield a clear, creamy-white tinted stone, very fine-grained and of quite uniform texture, which makes a very handsome ornamental building stone. At some places it is pitted with occasional sand-holes, but at others stone of considerable size can be obtained free from these imperfections. It can be very readily worked into different shapes and even carved in fine figures in considerable relief.

There are doubtless many other localities where these lower beds of this formation yield equally good stones with those here described, but no other extensive quarries have, so far as I have been able to learn, been opened in them

SAINT PETER SANDSTONE.—The Saint Peter sandstone consists almost everywhere of somewhat rounded siliceous grains, sometimes entirely uncemented, forming beds of very pure sand, and sometimes cemented to a quite hard and durable stone, which is everywhere, however, where I have seen it exposed, very much cut up by irregular seams or joints, themselves filled with arenaceous material dividing the rock into angular fragments. The material of these seams, however, sometimes cements the fragments well together. The rock has some slight use as a building stone in the town of Portland, Jefferson county, and in the southwestern part of the state, but only for cellar-wall purposes.

At Red Rock, in the valley of the Pecatonica, in southern Iowa county, near Darlington, there is a remarkable exposure of this rock, which appears to have been an upheaval.

In the north side of this exposure a large quarry was opened in 1872 by William T. Henry, of Mineral Point, which was worked only one season. The stone was shipped to Chicago, but the heavy freight charges prevented the business from paying, and the quarry has remained unworked since. Better freight rates can now be had to Chicago and Milwaukee. Some of the stone has been sent to Chicago for trial, and if it meets with favor there the quarry is likely to be opened on a large scale. The stone can be obtained in blocks as large as 6 foot cubes, apparently without flaws. It is, however, much cut up by the fine, irregular seams alluded to above, and it seems

doubtful whether the desirable deep tint of brown is the color of more than a small portion. The stone in the railroad cut approaches a brick-red in color, and this grades to a deeper color, nearly brown at the quarry spot, beyond which it gradually passes into a grayish-pink. It is in general appearance much the handsomest building stone found in that part of the state, but some considerable stripping of worthless stone will be required should the quarry be extensively worked.

TRENTON GROUP.—The Trenton group in Wisconsin contains two rather distinct divisions—the Trenton limestone and the Galena limestone.

The Trenton limestone or blue and buff beds furnish, wherever they occur in the southwestern part of the state, in what is called the Lead region, an excellent and durable building stone, but not often a handsome one. The buff beds, the lower, occur in layers from 6 inches to 2 feet, and sometimes thicker, and furnish a rather coarse, hard, somewhat unevenly-textured stone which is not difficult either to quarry or to shape and work. Its color, owing to uneven leaching, is usually, or at least often, blue at the center of the layer, but a decided buff for some inches from the bedding-planes, while often stone taken from near the natural surface is leached throughout to a buff color. The blue beds in that region usually furnish a very thinly-bedded, hard, dark grayish-blue to dark drab, fine-grained, often fossiliferous stone of pretty uniform texture, rarely occurring in layers thicker than 10 or 12 inches and not obtainable in very large blocks. At some places these beds remain unchanged by leaching, at others the leaching affects their color almost as much as it does the buff beds. They furnish very hard, durable stones, which are very hard to dress, but take a very fine, soft-feeling polish, and often, because of the fossils included, present a very handsome appearance. These beds have been considerably worked at many points in the Lead region, as at Mineral Point, Darlington, Mifflin, Platteville, Highland, etc. There are, so far as I could learn, no quarries now worked on a sufficient scale, or enough distinguished in former working from hundreds of others, to warrant a special report.

In the adjoining parts of Saint Croix and Pierce counties there is a considerable area where the bluffs are everywhere capped by the Trenton limestone, often only the buff beds; and this is quarried in a number of places, notably at Gibson's quarry, near Hudson, and in Walker's quarry, at River Falls. They present here almost exactly the same physical characteristics as in southwestern Wisconsin, and furnish an excellent and durable though not a handsome building stone. Owing to their position close to the surface the beds are more generally leached to a solid buff color.

In the southeastern and eastern portions of the state the blue and buff beds present very little marked difference in texture and physical characteristics, the heavier and more regular beds being still characteristic of the lower beds or buff, and that being much the more profitable portion of the formation for quarrying. The blue beds generally furnish little or no material fit for other than the commonest masonry, while deep quarrying into the buff (away from the originally-exposed surface) often develops a bluish graystone of rather rough, uneven texture, but suitable for a fair quality of the ordinary ornamental building stone. The quarries in these beds in the eastern and southeastern parts of the state, upon which special report has been made, are those at Beloit, at Janesville, and at Neenah and Menasha. Along the line of its outcrop, as it passes from the northeastern part of the state southwest and then bends to the westward and southwestward, and also where it outcrops in the Lead region, are very arenaceous small quarries.

The upper bed of the Trenton group, the Galena limestone, is the surface formation over a large area in the Lead region and extends in quite a wide band southeastward into Illinois, then bends to the northward nearly parallel with lake Michigan, and at a distance of from 25 to 50 miles inland to and across the state line into northern Michigan.

In the central and eastern part of the Lead region the stone of this formation is everywhere of the same brown or yellow color, often much iron-stained, and also somewhat rotten and honey-combed throughout with large cavities often an inch or more in diameter, almost everywhere unfit for any building purpose, though sometimes compact enough for rough cellar-wall work, and is occasionally used for that purpose.

There are several horizons, however, at which, when it is exposed, it furnishes an excellent, heavily-bedded, rather coarse-textured, strong and durable building stone, well fitted for ordinary and heavy masonry. These beds outcrop at Cassville and along the Mississippi River bluffs in western Grant county, and in numerous other places in that part of the Lead region.

In the southeastern part of the state for some 60 miles north of the state line the Galena limestone has the same physical characteristics as distinguish it in the central part of the Lead region.

At Watertown, however, beds of sufficient firmness and freedom from honey-combing are found to furnish a fair building material. From here northward the stone gradually undergoes a change, mainly through the addition of argillaceous material, which very materially affects for the better its appearance and usefulness as a building stone.

At Waupun a large quarry was once worked in this formation, which furnished an excellent coursing stone.

At Oshkosh are two large quarries which furnish a dark drab stone of considerable hardness and durability, but which dresses with much difficulty, and has been little used heretofore for facing or for ornamental purposes.

Northward from here there are no noteworthy quarries in this formation until we reach the rapids in the Fox river at Kaukauna, where large quarries have been opened and great quantities of unusually large dimension stone taken out. Here is opportunity for opening many extensive quarries in stone of a most excellent character for all mason work, except that requiring the very finest of finish.

Many of the government locks on the Fox river have been built with this stone and others are to be built.

The stone is a medium-textured, light drab or gray limestone, and occurs in beds from 6 to 30 inches thick, from any one of which it can be split in almost any required size, and it can be quarried for dimension material almost if not quite as cheaply as for rubble.

The quarries at Duck creek, on the Chicago and Northwestern railway, near Green Bay, are in exactly similar rock, and have furnished the railway with large quantities of a most excellent stone for bridge purposes.

NIAGARA GROUP.—The Cincinnati shales, *i. e.*, limestones, furnish no building stone. The only Upper Silurian formation in Wisconsin furnishing any building stone is the Niagara limestone. This formation is the surface rock in a strip of country 30 to 50 miles wide along the shore of lake Michigan. There are four well-recognized subdivisions of the formation, which maintain the characteristics with considerable persistency throughout the whole country where the formation is exposed: 1. Guelph beds; 2. Racine beds; 3. Waukesha beds; 4. Mayville beds.

The lower of these, the Mayville beds, forming the surface rock in the country adjoining that immediately underlaid by the Galena limestone, contain some beds which furnish stones fit for ordinary building purposes, but no especially noteworthy quarries. In the upper part of these beds there is, in some places in Fond du Lac county and the counties immediately adjoining, a very pure calcareous sandstone, whose occurrence has been mentioned in the reports upon the quarries in the vicinity of Fond du Lac. It is a pinkish-gray stone of varying compactness, which cuts with very great ease and seems to harden some upon exposure. It would be a valuable building stone but for the fact that no spot has yet been found yielding a large quantity of stone of even a tolerably uniform character, or from which pieces of large size could be taken out.

The Waukesha beds throughout Waukesha county furnish a hard, compact, very light drab, sometimes nearly white dolomitic limestone, which yields an excellent, fine-appearing, and durable building stone suitable for all grades of construction. It is quite a hard stone to cut and finish, but presents a handsome appearance when dressed. The typical occurrence of these beds is in very thin sheets, from 1 inch to 6 inches thick, very well fitted for flagging, but these often unite to form much heavier ones, furnishing stones of almost any ordinarily required size. The quarry of the Hadfields, at Waukesha, is the largest and most worked, and sends considerable quantities of stone to Milwaukee and many other Wisconsin towns. In the quarries owned by these gentlemen the typical Waukesha beds yield flagging stones and heavily-bedded building stone. Throughout the country where these beds occur are numerous excellent quarry spots awaiting development. South of this point there is a considerable quarry, 2 miles from Genesee station, which furnishes some stone rather easier to work and somewhat freer from slight defects than the Waukesha.

Northward also from Waukesha these beds have been worked at a number of places and furnish fine flagging material especially. In the country to the northward where these beds emerge from under their intermediate heavy drift covering their stratigraphical equivalent presents three very well-marked divisions, the first only of which furnishes any considerable amount of valuable building stone. This division, called Byron beds, from having its most marked exposures in the town of Byron, Fond du Lac county, forms in that county what is called "the ridge" and "the ledge", a considerable rise of ground, with an abrupt and rocky western face, which runs southward, swinging somewhat westwardly, just east of Fond du Lac, and which is quarried at numerous places near that city, as, notably, at Eden and Oak Centre, and at Sylvester, in Green county. Here good building stone—a compact, medium to fine textured and quite homogeneous limestone—is obtained for ordinary and ornamental purposes, though somewhat hard to shape, and fine flagging stone of any required thickness between 1 inch and 8 inches. Many quarries have been opened in the ledge, but only a minute fraction of the easily-quarriable stone has been as yet uncovered. These beds pass to the east of lake Winnebago, through Calumet county, where they occur in places as a very pure white and sometimes handsomely-mottled stone, which is locally called marble, and can be polished fairly well, presenting a handsome appearance and being well fitted for ornamental building stone. The two upper divisions furnish very little material fit even for ordinary building purposes.

The Racine beds, which rest upon the Waukesha beds at the south and the upper coal beds at the north, are the surface rock along and parallel to lake Michigan, from the state line on the south to the extreme end of Door county on the north, attaining in places a width of 30 miles. They are beds of quite pure dolomitic limestone, and present a great variety of texture and structure, from a porous, granular, and irregularly-bedded to a fine, compact, homogeneous, and evenly-bedded rock. They are very extensively quarried, and furnish most excellent common and fine building material at a great many points, notably at Milwaukee, Cedarburg, Grafton, Sheboygan, and Manitowoc. The Racine quarries in these beds have furnished large quantities of ordinary building stone and stone for lime, but very little material well fitted for ornamental and the finer classes of stones. The Milwaukee quarries furnish every grade of building material and almost any necessary size, and are remarkable for the great depth of excellent building stone which their working has developed.

The Guelph beds, forming the uppermost series of the Niagara group, have pretty much the same general physical characteristics as the Racine beds upon which they rest. In a number of places they furnish excellent building stones, similar to those of the Racine beds. They skirt the shore of lake Michigan as far north as Kewaunee county, and are somewhat quarried at Cedarburg and Grafton, and at Sheboygan.

The Niagara group as a whole furnishes by far the largest number of extensive quarries of any formation in the state, and almost the only ones, except the few in the Archæan, in which the depth of excellent stone is more than a few feet, and which therefore warrant the expenditure of large sums of money in removing the covering. For this reason the number of places in this formation where quarries can be profitably worked is very large.

None of these quarries as yet opened are in convenient proximity to the lake, so that the development of these, as well as of all those valuable Archæan quarries inland, will depend upon transportation facilities furnished by railroad companies.

ARCHÆAN.

The vast area in northern central Wisconsin which is underlaid by the Archæan rocks is almost everywhere covered with an irregular but heavy covering of glacial drift, and there are large areas where rock exposures are very rare. A large part of the stones of this formation are of a character unfit for building or ornamental purposes. Several localities have, however, been pointed out by Professor R. D. Irving in his report upon the geology of central Wisconsin (*Wisconsin Geological Report*, Vol. II) as likely to furnish valuable building and ornamental rocks.

At Little Bull falls, on the Wisconsin river at Mosinee, Marathon county, are large rock exposures of a greenish-gray mottled syenite, much of which would furnish a handsome and excellent building and ornamental stone, and which could be quarried with great ease. A very similar rock is found on the Eau Claire river, at the crossing of the Stevens Point and Wausau road, but is here coarser than that variety of the Little Bull Falls syenite which is best fitted for building purposes.

A short distance west of Wausau, in the southeast quarter of section 21, township 29, range 7 east, is a small granite quarry owned by Mr. Kolter, on which a special report has been made. The stone has some considerable local value. The ridge upon which this quarry is located extends 3 or 4 miles. A rock very similar to this is also found on the south side of the valley of Little Rib river, on the southeast quarter of section 29 in the same township, but it is not exposed.

At the falls of Rib river there is found a heavily-bedded greenish syenite, which breaks readily into rectangular blocks.

In the valley of the Wisconsin river, around Grand Rapids, Wood county, there are numerous exposures, natural and artificial, of reddish granites, some of which could be easily quarried for building stone, but most of them show a decided tendency to decompose upon exposure. At Grand Rapids there is exposed in the bed of the river, at low water, a deep red, handsome granite, which would probably have considerable value as a building stone, and could be quarried quite readily during times of low water. The amount of quarriable rock is not, however, very great.

In the valley of Yellow river are some exposures which merit special attention.

In Hemlock creek, at the crossing of the wagon-road from Grand Rapids to Dexterville, is a fine-grained, flesh-colored granite, which, though showing some tendency to weather and even to stain, would furnish a very handsome, readily-dressed rock.

On Yellow river, at Big Bull falls, on sections 15 and 16, township 24, range 3 east, are large exposures of a medium-grained red granite extending along the bed and banks for a quarter of a mile. It is an unusually fine stone, taking a handsome polish. Polished specimens were exhibited in the Wisconsin collection at the centennial exhibition at Philadelphia, where they were regarded as among the finest of the polished granites exhibited.

On section 3, township 22, range 3 east, 3 miles north of Dexterville, there is in the bed of the river a greenish-gray quartz-porphyry similar in texture to those of the isolated Archæan patches in the southern part of the state.

At Black River Falls there is in the bed and along the bank of the river a continuous and large exposure of medium-grained pinkish granite. There are several spots where extensive quarries could be opened. The Chicago, Milwaukee, Saint Paul, and Ohio railroad crosses the river at the town, and convenient facilities for loading and transporting the granite could probably be arranged for. Specimens of this rock were taken.

On Black river, in the stream, about 1 mile above Black River station, is a ledge 25 feet high and 150 feet long of fine-grained, dark reddish granite.

Above the mouth of its east fork there are exposures and ledges of red granite as far as to French's mill, in section 25, township 23, range 3 west. At the mill the exposures are large; the stone is reddish, fine-grained, and uniform-textured, and would make a handsome building material.

Three-quarters of a mile west of Neillsville, where the wagon-road crosses Black river, on southwest quarter of section 15, township 24, range 2 west, is a fine grained, light pinkish, slightly gneissoid and very quartzose granite, hard and compact, and which appears to be a very fine ornamental granite.

The gneissoid and red granites of Black and Yellow rivers resemble one another closely and appear to be directly continuous with one another underneath the sandstone, which nearly everywhere between the two rivers is the surface rock. Occasionally the crystalline rocks come to the surface in the interval, and are then of the same character as in the rivers, as for instance on O'Neill's creek, in section 182, in township 24, range 1 west, Clark county, where red granite is exposed; and on a high bluff in the northeastern part of township 23, range 2 east, whose upper portions are reported to be of red granite, with sandstone layers at lower levels. (*a*)

These notes show quite conclusively that there is in the southern and southwestern parts of the main Archæan area of central Wisconsin and its branches a large number of localities where are found granitic and syenitic rocks of excellent quality for building and ornamental purposes, in many of which the rock can be readily quarried, and it seems probable that in course of time these stones will find their way into the market.

Beside the main Archæan area there are in the southern central part of the state a number of small patches or islands of granite, quartz-porphyry, and quartzite projecting through the overlying Silurian rocks. Previous to the census year no regular quarrying had been done in these rocks, but at the close of that year a great demand arose in Chicago for paving stones of a durable character, which led to the opening and working for that purpose of several quarries in these outlines, which happened to lie near the means of transportation to that city.

Owing to their nearness to the thickly-settled portions and great cities of Wisconsin and Illinois, and to means of transportation, these small areas all seem likely to sooner or later become important centers of the quarrying industry.

At the present time the most important quarry of these areas is that at Montello, where a medium-grained, dark, rather dull pink granite is quarried. It was first opened chiefly to obtain paving stones for Chicago, but has from the first furnished considerable quantities of building and ornamental granite. The stone takes a fine polish, but owing to its small grain and the even distribution of the constituent minerals its appearance is not as showy or handsome as that of many other granites. It is a very durable and reliable stone, having also apparently great strength. The extent of quarriable rock is very great.

The quarry near the village of Waterloo, Jefferson county, in an outline of nearly white quartzite, is perhaps next in importance. It furnishes as yet only paving stones and macadam material. The paving blocks are split more smoothly and regularly than any others I have seen in Chicago from the east or from Wisconsin. They appear harder and likely to be more durable than those from the Montello quarry. An attempt is being made to get this stone out in large blocks adapted for building and ornamental purposes.

A quarry has been opened in the Moundville quartzite-porphyry, which also is worked only for paving blocks, all of which have as yet been sent to Chicago. Monroe street, from State street to Wabash avenue, in that city, has been paved with it. The stone is very hard and well suited for that purpose, and blocks out easily though somewhat roughly into pieces of requisite size. The stone takes a very handsome polish and is very dark, almost black, when so finished.

Some 5 or 6 miles from Portage, at the east end of the ranges, a quantity of jasper has been taken out, and some citizens of Portage are experimenting with it to learn its value. The pieces taken have been handsomely polished and present the appearance of beautifully-grained dark mahogany. I have been unable to learn whether the locality yields large quantities of this stone, and whether it can be obtained in blocks of considerable size, but I judge from reports that the only difficulty anticipated by the owners is that of properly shaping the pieces taken out.

The following description includes fuller statements as to some localities already named:

On the line of the Wisconsin Valley railroad, between Centralia and Junction City, are several deep cuttings, which expose usually crumbling and partially-decomposed laminated gneissic rocks. The exposures are very poor and the rock is generally out of position. About 3½ miles north of Centralia is a cutting 400 feet long, through a rather fine grained, granular-textured, pinkish granite. This rock consists of brownish, translucent, granular, glassy quartz largely predominating; pinkish bright-lustered feldspar, and fine black mica sparsely but uniformly scattered. It would dress readily, but shows some tendency to weather and iron stain.

At Little Bull falls, on the Wisconsin river at Mosinee, Sec. 29, T. 27, R. 7 E., Marathon county, are quite large rock exposures. The river here is divided into two widely-separated channels by a high, rocky island about a quarter of a mile in width. On its northeast end this island is itself cut by several smaller channels, dry at low water, which show high walls of bare rock. Most of the water of the river passes through the easternmost channel, which in one place, for a distance of 130 feet, is a gorge only 35 feet wide. The main fall of the river was formerly in this gorge, but has lately been moved down stream by a dam erected below. The rocks of the various exposures at this place are all closely allied and may be designated by the general term of syenite. They are all characterized by the presence of much greenish-black amphibole and white striated feldspar, the quartz, though present, being always subordinate. Two general kinds were noted. The prevailing rock is a moderately-coarse grained, highly-crystalline syenite, with a greenish-gray mottled appearance, and without any sign of parallel arrangement of the various ingredients, which are uniformly intermingled. On a weathered surface this rock appears greenish to white, the latter color being due to a kaolinization of the feldspar. On a fresh fracture the two main ingredients are readily perceptible to the naked eye. The hornblende is usually of a bright-lustered,

a Wisconsin Geological Report, Vol. II, p. 504.

greenish-black color; the feldspar facets are commonly white, translucent, and beautifully striated, as can readily be seen with an ordinary lens. More rarely pinkish feldspar occurs. That variety of this rock which has a medium degree of coarseness presents a very handsome appearance on a dressed surface, and, since it shows no tendency to iron-stain or decompose, might make a valuable building stone. The second variety found here is very much finer in grain, and of a dark greenish-gray color, showing the crystalline texture only under the lens, and then not plainly. It is evidently merely a phase of the coarser rock. It occurs both in small embedded patches and in large, distinct outcrops. According to the microscopic examination these finer kinds, while having the same ingredients as the coarser, show a larger proportion of hornblende, and may be designated as "hornblende rock". Chlorite appears to occur in all, more especially in the finer kinds, as an accessory.

On the Eau Claire river, at the crossing of the Stevens Point and Wausau road, Sec. 7, T. 28, R. 8 E., there is a fall over coarse pinkish syenite resembling that on the Wisconsin river near the Mosinee hills, and also the prevailing syenite at Big Bull falls, a short distance northward.

On the upper Eau Claire, in Sec. 4, T. 29, R. 10 E., are exposures of a very coarse, rough-textured, feldspathic granite, consisting of pink, cleavable feldspar, very large-flaked black mica, and gray quartz.

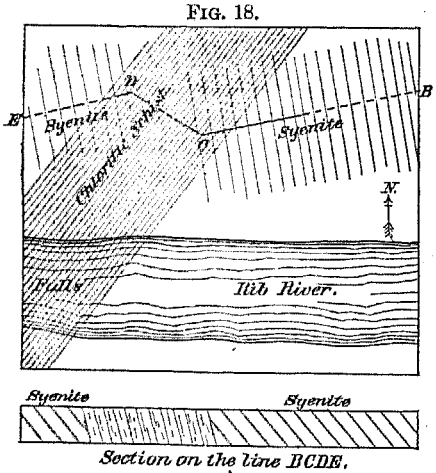
Westward from Wausau, in T. 29, R. 7 E., a number of outcrops occur. Near its south line this town is traversed by Rib river. In Secs. 21, 22, 27, and 28 there is high ground trending north and south, which rises from 200 to 300 feet above the Wisconsin at Wausau. In the S. E. quarter of Sec. 21, on the south slope of part of this ridge, a peculiar, fine-grained feldspathic rock is exposed and is quarried to some extent on Mr. Kolter's land. This rock has a brownish-pink color, the least weathered portions showing a grayish tinge; it is rather fine grained, and has a marked granular texture, looking almost like a mechanical rock. The most abundant ingredient is a pinkish feldspar in cleavable fragments up to one-twentieth of an inch across. With this is much granular brownish quartz, and a little blackish mica in fine flakes, making the rock a granite. No arrangement of the minerals in parallel lines is perceptible. In the quarry the rock is seen to be nearly horizontal, dipping not more than 10° in a due south direction. A total thickness of about 3 feet was seen. Large thin slabs, from 2 to 4 inches thick, splitting off parallel to the bedding, can be obtained.

Near Single's mill, in the north part of the S. E. quarter of Sec. 29, in the same township, and on the edge of a part of the same high ground, are exposures of a whitish, slaty, granular quartzite, in places iron-stained. Under the magnifying glass this rock is seen to be made up of rounded grains of glassy quartz, and some few places were noted where the variety with granular texture grades into a non-granular, glassy quartz. Scales of silvery mica occur on the surfaces of laminæ. The bedding structure is distinct, and shows a strike of N. 75° E. and dip of 56° S. E.

About half a mile from this place, and on the south side of the valley of Little Rib river, S. E. quarter of Sec. 29, the northeast face of the ridge shows quartzite in large exposures. The rock here is glassy, translucent, and occasionally iron-stained, resembling that of Rib hill. The bedding is obscure. On the slope of the hill below, the roots of the trees of a heavy windfall have upturned numerous fragments of a brownish-pink, granular-textured feldspathic rock, similar to that at Kolter's quarry in Sec. 21. Half a mile northeast on the north face of the same elevation, N. E. quarter of S. E. quarter of Sec. 30, a high ledge shows the same feldspathic rock, striking N. 80° E. and dipping 50° N. W.

At the falls of Rib river, S. E. quarter of Sec. 28, T. 29, R. 5 E., are large exposures of greenish chloritic schist and syenite. On the south side of the river, at a point near the lower left-hand corner of Fig. 18, is a rocky point about 15 feet high, showing heavily but distinctly bedded greenish syenite, dipping 20° E. and striking N. 8° W. The uppermost layer, about 3 feet thick, is moderately-coarse grained, mottled green and gray, weathering white. To the lens it shows much grayish quartz, green amphibole, and white altered feldspar, the last least abundant, though coarsest of the three. In some specimens greenish chlorite accompanies the hornblende. The next layer below, 4 feet thick, is a very much finer grained, almost aphanitic, greenish-gray rock, containing apparently a good deal of chlorite. The weathered surface is white, with numerous green, epidote-colored blotches. Microscopic examination shows that the ingredients of this fine-grained rock are the same as those of the coarser one above, but that the amphibole and feldspar are both more altered. This rock breaks out very readily into rectangular blocks, the planes of easiest cleavage lying at right angles to the bedding. The lowest layer, 3 feet thick, is again of coarse variety like that of the uppermost bed.

FIG. 18.



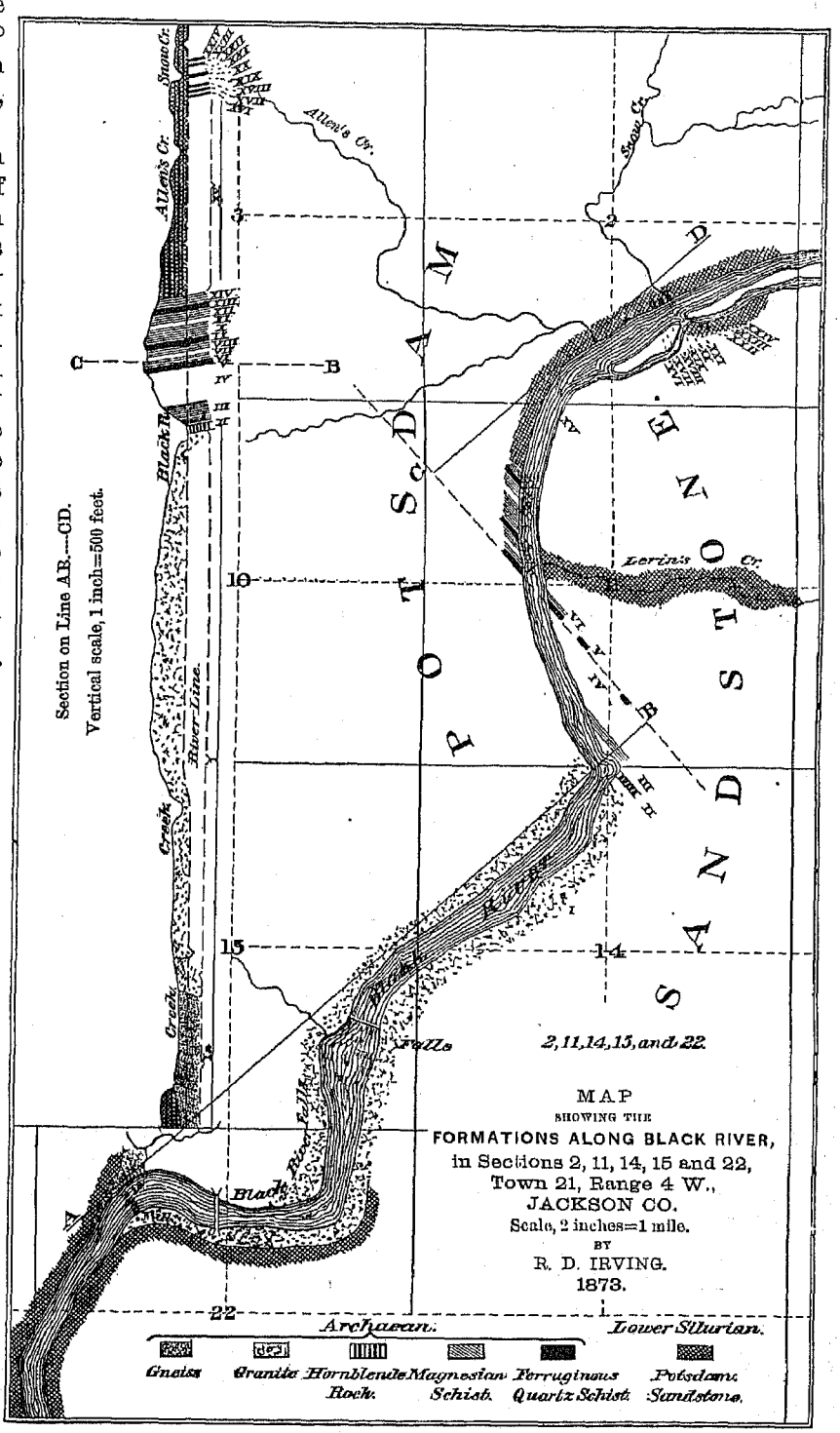
Section on the line BCDE.

ROCK OCCURRENCES AT THE FALLS OF RIB RIVER.
Scale, 1 inch=50 feet.

At Hemlock creek, at the crossing of the wagon road from Grand Rapids to Dexterville, in the N. E. quarter of the S. E. quarter of Sec. 5, T. 22, R. 4 E., are ledges of rather fine grained, flesh-colored, gneissoid granite. Translucent, wine-colored quartz, and pinkish orthoclase, in small brilliant facets, make up most of the rock; the mica is sparse, in fine, green-black flakes, which have a distinct linear arrangement. This rock is a handsome one, and would probably dress well, though showing some tendency to weather and iron stain. The bedding directions appear to show a strike of N. 60° E. and a dip of 70° S. E.

On Yellow river itself, the southernmost Archæan exposure is to be seen about 2 miles north of Dexterville, in the N. half of Sec. 14, T. 22, R. 3 E. The rock here is medium-grained, pinkish, quartzose, gneissoid granite composed chiefly of limpid quartz and orthoclase feldspar, the former the most abundant. Mica is present in fine black scales arranged in parallel lines. The strike appears to be N. 55° W. and the dip 60° S. W. Near the top of the river bank, which rises directly from the granite, thinly-bedded, friable, horizontal sandstone is exposed.

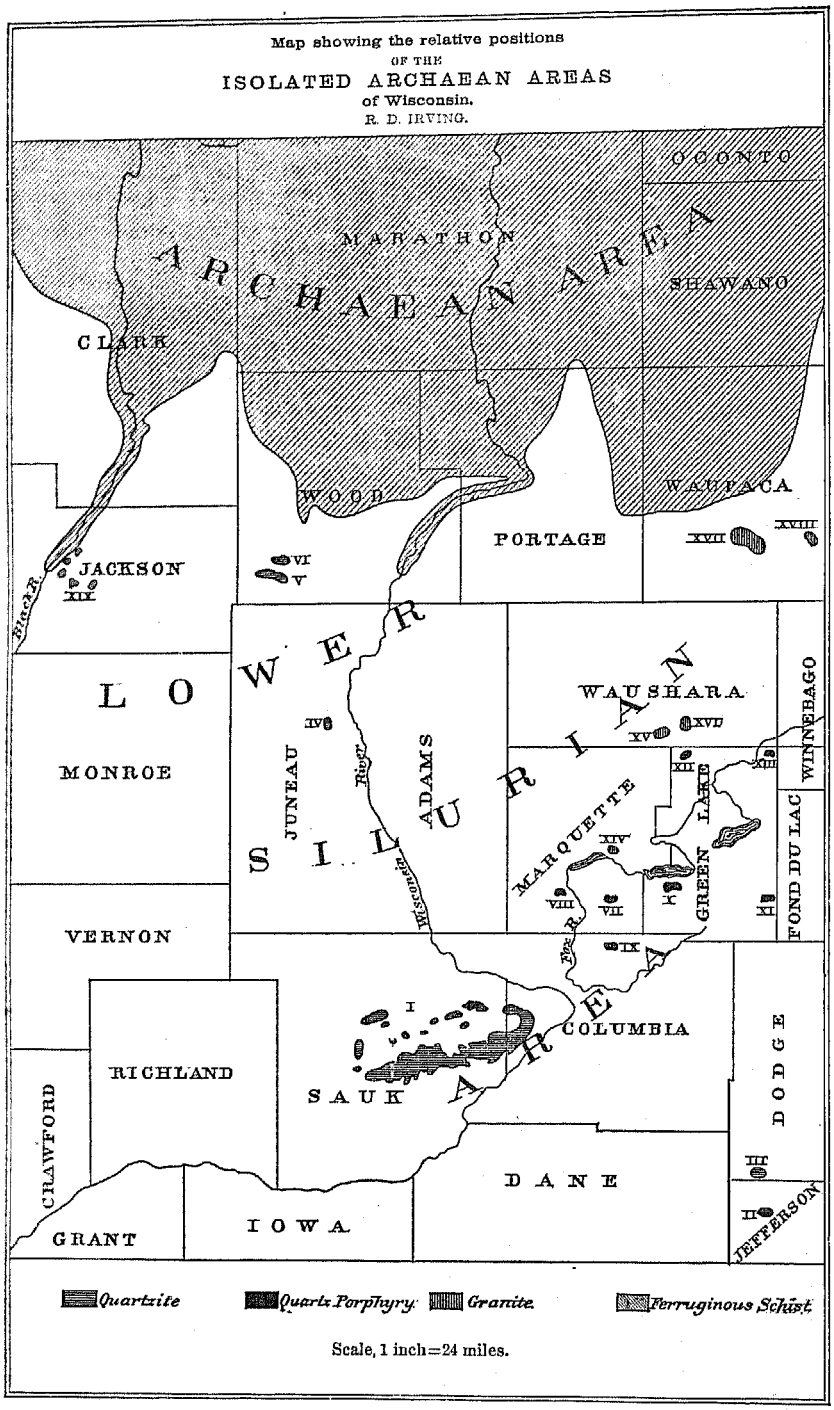
On Sec. 3, T. 22, R. 3 E., 3 miles north of Dexterville, there are large flat ledges of gneiss in the bed of the river, bounded on the north by quartz-porphyry. The gneiss is very fine grained, laminated, dark gray to black in color, and consists of a black mineral (mica, hornblende, or both), in small brilliant flakes; and whitish quartz and feldspar. Its weathered surface is earthy and of a dirty white color, but shows the fine lamination even more distinctly than the interior. The quartz-porphyry consists of a light greenish-gray, aphanitic matrix, having the peculiar flaky appearance that is characteristic of the quartz-porphyries of the various isolated Archæan patches of Wisconsin, in which are embedded somewhat sparsely scattered facets of pinkish orthoclase feldspar up to one-sixteenth of an inch in diameter. It is a very tough, compact, rock, and is worn by the running water into smoothed and polished surfaces. This porphyry appears to penetrate the adjacent laminated rock in a very irregular manner. In one place a mass of the gneissoid rock some 50 feet in diameter is nearly surrounded by the porphyry, the lines of junction between the two being very sharp, and rendered especially noticeable by the different appearances of their weathered surfaces. The lines of junction are not curved, but straight, bearing respectively N. 70° W., W. 20° E., and N. 70° W., the first and last upon opposite sides of the inclosed mass. The strike of the gneiss is N. 25° W., its dip 60° N. E. The porphyry is from 20 to 30 paces wide, and appears to be bounded on the north by the same gneiss as before, with the same bedding. Beyond, porphyry comes in again.



At Big Bull falls, 9 miles north of Pitt's mill, on Secs. 15 and 16, T. 24, R. 3 E., large exposures of medium-grained, highly feldspathic, red granite extend along the bed and in the banks of Yellow river for a quarter of a mile. This granite has a base of cleavable reddish orthoclase, throughout which is quite uniformly distributed hyaline, occasionally smoky, and quartz in irregularly-shaped patches from one thirty-second to one-quarter of an inch in diameter. Mica is present, but is very fine and sparse. For the whole length of the exposure this rock is nearly uniform, and without any tendency to kaolinize. Its peculiar texture, composition, and color combine to make it a very valuable and unusually handsome building granite. Polished specimens of the rock attracted great attention at the Philadelphia exposition, where it was regarded by experts as among the finest of the many polished granites exhibited.

On Sec. 7, T. 24, R. 3 E., another exposure of a similar red granite was noted. Above this point Yellow river is reported without exposures.

BLACK RIVER VALLEY.—The first exposures of crystalline rocks met with in ascending Black river are found a short distance below the town of Black River Falls, T. 21, R. 4 W., in Jackson county. From here they occur in the bed and on the sides of the stream, with only occasional interruptions, as far north as town 28, in Clark county. For the greater part of this distance they are concealed away from the river by overlying horizontal sandstone, through which, however, they occasionally rise in knobby projections. In some of the branch streams also the sandstone is cut through and the crystalline rocks exposed. Along the river the rock ledges in few places only rise to any considerable height above the water.



Granite: Medium-grained pinkish, consisting of a nearly uniform admixture of pinkish orthoclase, in facets up to one-sixteenth of an inch, and fine-grained, translucent quartz. Some mica is present, in fine scales, showing sometimes a slightly stringy arrangement. This granite is exposed from a short distance above the wagon bridge as far north as the north line of Sec. 14, the river in this distance passing through a gorge whose walls sometimes reach a height of 80 feet. In the large exposures at the falls the parallel grain of the gneiss below is almost entirely lost, being only occasionally indicated in an obscure arrangement of the mica. The rock here is traversed by several sets of joints, mostly somewhat irregular, those showing the greatest irregularity trending N. 80° E. and dipping 72° S. E., but having no corresponding structure in the rock. The granite shows the same general character above as at the falls, occasionally—as in the railroad cut on the west side of the river, just above the falls—showing a darker kind than usual from a greater quantity of fine dark mica. In this cut there are to be seen two sets of planes equally marked, one set trending N. W. and dipping N. E., the other trending N. E. and dipping N. W. A distinct stringy arrangement of the mica was noted parallel to the former set. Near the north line of Sec. 15 the granite exposures cease suddenly on the east side of the river, while they continue some distance farther on the west side—a fact to be explained by the northwest strike of the succeeding slaty rocks.

In the river one mile above Black River station on the Green Bay, Winona, and Saint Paul railroad, a ledge 150 feet long and 25 feet high is seen of fine-grained, dark reddish granite, consisting of a rather uniform and close admixture of reddish orthoclase, in fine glittering facets, reddish-brown, translucent quartz, some colorless quartz, and a little, sparsely scattered, fine black mica. Half a mile farther up stream, fine-grained red and gray banded quartzose gneiss is exposed. The gray bands consist of fine-grained, glassy quartz, fine black mica, and white feldspar; the red of brown and red translucent quartz mingled with a little orthoclase. From here to the mouth of the East fork the bed of Black river shows numerous small ledges, 3 to 4 feet high, of contorted gneiss and reddish granite.

Above the mouth of the East fork, which is on Sec. 36, T. 23, R. 3 W., exposures of red granite are seen as far as French's mill, on Sec. 25. The wagon-road, which for half a mile below the mill follows the west bank of the river, has, on the east side, ledges of red granite and on the west a ridge 30 to 40 feet high composed of horizontal, coarse-grained, quartzose, cross-laminated sandstone. In one place the exact junction of the two formations is to be seen. At the mill the granite exposures are especially large, both on the west bank and on a large island in the stream. Two kinds of the granite occur, both presenting a prevailing pinkish weathering: (1) a rather fine-grained, very uniform-textured, dark reddish kind; and (2) a medium-grained, uniform-textured, pinkish-gray quartzose kind, containing colorless, glassy, and pink translucent quartz, pink orthoclase, and fine black brilliant mica. Both kinds appear like handsome building or ornamental granites. No definite bedding structure is to be seen.

Three-quarters of a mile west of Neillsville, at the crossing of Black river, on the S. W. quarter of Sec. 15, T. 24, R. 2 W., fine-grained, light pinkish, slightly gneissoid, and very quartzose granite is exposed, with a vertical dip and E. W. strike. This rock is very hard and compact, and appears to be a fine ornamental granite.

The gneissoid and red granites of Black and Yellow rivers resemble each other very closely, and appear to be directly continuous with each other underneath the sandstone, which nearly everywhere between the two rivers is the surface rock. Occasionally the crystalline rocks come to the surface in the interval, and are then of the same character as on the rivers; as, for instance, on O'Neil's creek, in Secs. 1 and 2, T. 24, R. 1 W., Clark county, where red granite is exposed; and on a high bluff in the N. E. part of T. 23, R. 2 E., whose upper portions are reported to be of red granite with sandstone layers at lower levels.

The amount of these reddish ornamental granites of extraordinarily fine quality occurring on Yellow and Black rivers and in the intervening country appears to be very great.

The following table indicates the location, size, nature, etc., of the various Archæan outcrops in the Silurian area of the state:

ARCHÆAN OUTCROPS WITHIN THE SILURIAN AREA.

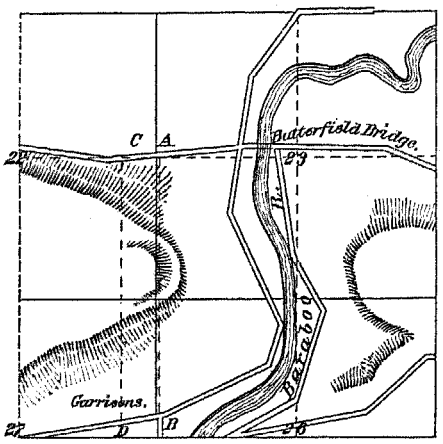
No. on the Fig. page 238.	Name of outcrop.	LOCATION. Sec.	T.	R.	County.	Approximate area.	Height of bluff.	Nature of rock.	Distance from main Archæan.
							Feet.		
I	Baraboo bluffs	.....	.....	.....	Sauk and Columbia.	75 square miles	100 to 700	Quartzite, quartz-porphyry, clay-schists, and quartz-schists.	60
II	Lake mills	24, 25	8	13 E	Jefferson	20 acres	Low.	Quartzite	90
III	Portland	33, 36	9	13 E	Dodge	$\frac{1}{16}$ square mile	50 to 75	Quartzite	84
IV	Necedah	19 / 24	18 / 18	4 E / 3 E	Juneau	$\frac{1}{8}$ square mile	175	Quartzite	28
V	South bluff	21, 22, 23, 25	21	2 E	Wood	3 square miles	200+	Quartzite?	10
VI	North bluff	1	21	2 E	Wood	$\frac{1}{4}$ square mile	200+	Quartzite?	6
VII	Observatory hill	7	14	10 E	Marquette	$\frac{1}{8}$ square mile	250	Quartz-porphyry	48
VIII	Moundville	5, 8	14	9 E	Marquette	$\frac{1}{16}$ square mile	40	Quartz-porphyry	48
IX	Marcellon	7	13	10 E	Columbia	$\frac{1}{16}$ square mile	75	Quartz-porphyry	52
X	Marquette	34, 35 / 2	15 / 14	11 E / 11 E	Green Lake	$1\frac{1}{2}$ square miles	75	Quartz-porphyry	50
XI	Pine bluff	36	15	13 E	Green Lake	$\frac{1}{8}$ square mile	100	Quartz-porphyry	54
XII	Pine bluff	2	17	11 E	Green Lake	$\frac{1}{16}$ square mile	100	Quartz-porphyry	30
XIII	Berlin	2, 3	17	13 E	Green Lake	$\frac{1}{4}$ square mile	50 to 75	Quartz-porphyry	30
XIV	Montello	9	15	10 E	Marquette	$\frac{1}{16}$ square mile	40	Granite	42
XV	Spring lake	27	18	11 E	Waushara	$\frac{1}{8}$ square mile	50	Granite	27
XVI	Marion	12, 13 / 7, 18	18 / 18	11 E / 12 E	Waushara	$\frac{1}{8}$ square mile	50	Granite	26
XVII	Waupaca	31	22	12 E	Waupaca	$\frac{1}{8}$ square mile	100	Granite, etc	.....
XVIII	Mukwa	25, 26	22	14 E	Waupaca	$\frac{1}{8}$ square mile	70	Granite	.....
XIX	Iron mound:								
	No. 1	31	22	3 W					
	No. 2	1	21	4 W					
	No. 3	12	21	4 W	Jackson	$\frac{1}{16}$ to $\frac{1}{4}$ square mile ..	75 to 200	Ferruginous quartz-schist	.....
	No. 4	17, 20	21	3 W					
	No. 5	14, 15	21	3 W					

Baraboo bluffs.—On the northernmost portions of the northern of the Baraboo ranges at the lower narrows of the Baraboo river, T. 12, R. 7 E., and also for a short distance to the westward, a great thickness of quartz-porphyry is to be observed. This porphyry resembles that of the several small porphyry areas of the adjoining portions of Columbia, Marquette, and Green Lake counties, and proves at once that we must regard these areas as part of the same formation as that which appears in the Baraboo ranges.

On Secs. 23 and 26, T. 12, R. 7 E., Sauk county, the Baraboo river passes the north quartzite range in a gorge known as the lower narrows of the Baraboo. The passage is nearly half a mile in width, the level bottom extending to the foot of the cliffs on either side. The cliffs rise 400 feet above the river, and show finely the great

beds of quartzite and associated strata. The gorge is much wider than needed by the small stream that now occupies it, and may, as already suggested, have been at one time used by the Wisconsin, as the valley of Devil's lake seems to have been. It is unlike the latter valley in having been, in part at least, formed first before the Potsdam period, as indicated by the way in which horizontal sandstone and conglomerate ledges occur around the heads of steep ravines that extend down the cliff toward the main gorge.

FIG. 29.



MAP OF THE LOWER NARROWS OF THE BARABOO.
Scale, 1½ inches = 1 mile.

Beginning with the north end we find, forming the north face of the range, in bold northward-sloping ledges, quartz-porphyry about 600 feet in width. This porphyry is for the most part dull red to pinkish on the weathered surface, which is a good deal altered, often iron-stained, and has generally a whitish undercrust. The least altered specimens show a brownish-pink matrix, through which are scattered, very thickly, large facets, up to one-eighth of an inch in diameter, of bright red cleavable feldspar, and, more sparsely, minute facets of a white kind. In nearly all specimens a few small greenish-black blotches, apparently composed of fine mica scales, occur, as also small iron-stained cavities, which often show linings of minute quartz-crystals. The porphyry is very distinctly bedded, showing an E. W. strike, and a dip of 58° to 60° N. Toward its lowest portions, and higher up on the bluff, it becomes gradually more slaty in character, the feldspar facets, though very numerous, becoming at the same time less well defined, and the surfaces of the laminæ becoming covered with a soft, greasy mineral. This finally changes to a distinct schist, (*a*) about 80 feet wide, containing a large proportion of the soft mineral, and allied to the greasy quartz-schists occurring at Devil's lake, but without transverse cleavage. Continuing the ascent of the bluff southward quartzite is seen lying immediately underneath the schist and forming the body of the ridge to the foot of its southern slope. At first this quartzite is much veined and seamed with reticulating veins of white quartz, in which fine specular iron is occasionally to be seen.

Marcellon.—On Sec. 7, in the town of Marcellon, Columbia county, on each side of the road in the south half of the section, are two low, rounded hills, 40 to 60 feet in height, of quartz-porphyry. The rock exposures are large and are much rounded and weather-worn, being separated into numerous bowlder-like masses by wide-open, earth-filled joints. The weathered surfaces have a prevailing pinkish tinge, giving the idea that the rock is largely composed of pink feldspar. On obtaining a fresh fracture, however, only a very few, sparsely scattered, minute feldspar faces are to be seen, the mass of the rock being composed of a brownish to blackish compact matrix. Two general varieties occur, one presenting a light brownish color, showing a tendency to flake off in fragments that are translucent on the edges, and containing no distinguishable feldspar crystals, the other having a dark gray to black matrix, in which are to be seen a few distinct crystals of feldspar and numerous copper-colored points of iron-sesquioxide. The rock has nearly the hardness of quartz, and fuses only with the greatest difficulty. A more siliceous character as compared with other quartz-porphyries of the state is thus indicated, and the indication is borne out by the content of silica—76.98 per cent.—as shown by analysis. We have evidently, in this case, a porphyry which, in its large contents of silica and in the sparseness of its feldspar crystals, approaches the true felsites (petrosilex hälleflinta). Quite a distinct and uniform set of bedding joints occurs, the strike being N. 32° E., the dip 65° to 75° N. W. Numerous cross joints traverse the rock, and, on weathered portions, cause it to fly into smooth-faced, angular fragments at the least blow of the hammer. The surrounding country is occupied by the Potsdam sandstone, which is exposed at many points.

Observatory Hill.—Six miles north of the Marcellon outcrop, in the S. E. quarter of Sec. 7, in the town of Buffalo, Marquette county, a knob of quartz-porphyry rises 250 feet above the general level and 490 feet above lake Michigan. On the flanks of the hill and up to a vertical distance above the base of 125 feet are horizontal sandstone ledges; above, to the top, are nearly continuous outcrops of porphyry, with a not very plain N. 32° E. strike and 60° N. W. dip. These bedding directions are the same as on the Marcellon outcrop.

Moundville.—On the edge of the Fox River marsh, at the head of lake Buffalo, on the line between Secs. 8 and 5, T. 14, R. 9 E., Moundville, Marquette county, are three low, rounded outcrops of quartz-porphyry. These are 5 miles, in a direction 10° N. of W., from Observatory hill, which is the nearest Archæan outcrop. No other rock shows in the neighborhood, the country being heavily drift-covered. The largest outcrop is on the east end of a low bluff 35 feet high and several hundred feet in length. There are quite marked appearances here of the same N. E. strike and N. 60° dip as seen at Observatory hill and in Marcellon. The rock has a dark brown matrix, resembling in this regard the Marcellon porphyry, from which it differs, however, in showing throughout traces of crystalline structure, and quite thickly scattered large brown feldspar surfaces. A few crystals are white and translucent. The weathered surface is often a bright pink color. Mr. Wright's microscopic examination shows that fine magnetite particles are abundant. Their existence is not rendered evident even by the use of the ordinary lens. The silica content is 72.76 per cent.

a This schist is probably non-magnesian, like the schists of Devil's lake, ordinarily called talcose.

Seneca (*Pine Bluff, R. 11 E.*).—A rounded elliptical knob of quartz-porphyry, 100 feet high, one-eighth of a mile long, and a quarter of a mile wide, lies on the north side of the White River marsh, in Sec. 2, T. 17, R. 11 E., Seneca, Green Lake county. The greatest extension of the hill is in an east and west direction. It is largely rocky, but there are no abrupt rock ledges, the exposures being almost entirely surfaces conforming to the general contour of the hill, and on a level with the surrounding sod. In places the slopes of the hill are covered with angular fragments apparently split off by frost. This is a peculiarity not noticed upon any of the other porphyry outcrops, and appears to be due to the large content of comparatively coarse cleavable feldspar. The hill is only about 2 miles south from the granite hills of Spring lake, in T. 18, R. 11 E., Waushara county. The surrounding country is marshy and drift-covered, and shows no outcrop of horizontal rocks. The loose fragments are many of them smoothed on one side, and some surfaces are most beautifully striated. Owing to the broken condition of the outcrop, no definite bedding planes were made out, though weathered specimens brought away show distinct traces of lamination.

This porphyry in its least weathered portions shows a light gray to whitish fine-grained matrix, in which, with the lens, can be seen what appear to be angular grains of quartz. The glassy feldspar crystals are also abundant. The weathered surface is brownish, with a kaolinized undercrust. Nearly all of the rock shows signs of weathering. The silica content is 76.39 per cent.

Marquette and Berlin.—The large outcrops of quartz-porphyry in Secs. 34 and 35, T. 15, R. 11 E., and Secs. 2 and 3, T. 14, R. 11 E., near the village of Marquette, Green Lake county, were originally regarded as within the central Wisconsin district, of which, however, by subsequent agreement, the Fox river was made the southern boundary. They will, therefore, be described by Professor Chamberlin, in whose district is also the outcrop at the city of Berlin, Green Lake county. As the writer has examined both localities carefully, he may be permitted to allude to the nature of the rock of each, for the sake of comparison. In the Marquette outcrops the prevailing rock noticed has a black, compact, flinty matrix, which is streaked with white non-continuous lines. These lines are for the most part very prominent, and are frequently much contorted, the whole rock having a very evident parallel grain. The feldspar crystals are minute and sparse. The silica content is 70.29 per cent. less than that of any other of the Wisconsin porphyries. The general course of the contorted laminæ points to the same N. E. direction of strike as is observed on the Marcellon, Observatory Hill, and Moundville outcrops.

The Berlin rock has a dark bluish-gray matrix, much streaked with white, and having a peculiar fine, granular, quartz-like texture as seen under the lens. The feldspar crystals are small, grayish to brownish, and rather numerous. The lamination is very fine and distinct, and often contorted, and the silica content 74.37 per cent.

Montello.—In the village of Montello, on the west side of Sec. 9, T. 15, R. 10 E., Marquette county, is an elliptical-shaped, rounded mound of pink granite, about a third of a mile in length and 40 feet high. Over most of the hill the rock is quite uniform in a fresh fracture, though presenting a weathered surface from bright pink to dull grayish-pink in color. The weathering is very slight, however, and the rock shows almost no tendency to decompose. It has a medium grain, close texture, is of a bright pinkish color, and without sign of arrangement of the ingredients in lines. These are: Rather large flaked, pinkish, cleavable feldspar, predominating; somewhat granular, fine, pinkish, translucent quartz, abundant; and greenish-black mica sparsely scattered in blotches made up of very fine flakes. In places thin, light green, epidote-colored seams occur. Somewhat irregular northwest joints traverse the rock, which is, however, for the most part structureless, and is quarried by firing the pieces that crack off, presenting a conchoidal fracture. On the north side of the west end of the mound occurs a vertical layer 3 feet wide, trending N. 55° E., of a soft, greenish, highly schistose, decomposing, chloritic rock. The least weathered specimens show a blackish color and some tendency to a crystalline texture. The vein is weathered down for 2 or 3 feet below the inclosing granite walls, both of which are seen. The schistose laminæ are parallel to the walls. Greenish epidote seams in the rock near by have the same trend as the vein. Though this granite may be somewhat difficult to obtain in dressable masses, it would probably make a very handsome and durable building and ornamental stone.

Necedah.—Dotting the great sand plain of the Wisconsin in Juneau and Adams counties are numerous bold, castellated outliers of the Potsdam sandstone rising abruptly from the plain and constituting very marked features of the scenery. From the same plain, and only about 3 miles west from one of the greatest of the sandstone bluffs—Petenwell peak—rises the quartzite hill at the foot of which the village of Necedah is built. The rounded contour of this hill serves to mark it at once as different in nature from the sandstone bluffs of the adjoining region.

The main Necedah bluff lies on the N. W. quarter of Sec. 25, T. 18, R. 3 E., the town line crossing over its eastern end; it is about half a mile in length, with its greatest extension east and west, and is highest and at the same time most bold and rocky on its eastern end, which rises 170 feet above the street below and about 510 feet above lake Michigan. A short distance southeast of the main bluff, on the N. W. quarter of the S.W. quarter of Sec. 19, T. 18, R. 4 E., is a small, craggy hill, 75 feet high, of the same rock as that composing the main hill, the intervening low ground being underlaid by horizontal sandstone.

The exposures on the main hill are mostly on the eastern and southeastern portions, where in places they rise nearly precipitously from the low ground at the foot. The rock seen here is for the most part a glassy, translucent, subgranular, grayish quartzite, much more nearly allied to the quartzite of the Rib and Mosinee hills, in Marathon county, than to that of the Baraboo ranges. Much of the rock is quite dark gray in color, the quartz then

being still glassy, but smoky-tinted. Numerous small cavities and seams occur lined with half crystalline quartz and carrying a soft, pinkish, clayey substance; bluish-white quartz veins, ½ inch to 2 inches in width, and nests are also common, and these carry frequently fine-flaked, brilliant, specular iron, which occurs also occasionally in quite large masses, similar to those found in the Baraboo quartzite. No parallel grain is to be seen in this rock, nor any definite bedding planes. Numerous quite close joints occur, however, and these cause the rock to weather into smooth-faced, sharp-angled fragments. On the smaller bluff a very distinct parallel grain is to be seen trending N. 75° W., and showing a corresponding dip of 45° N. Here much of the quartzite is of a light pink color, looking, on a fresh fracture, almost like a fine-grained, pinkish granite, but the only prominent mineral is subgranular, translucent, pinkish quartz. Some specimens show mica plainly in very sparsely scattered small scales. In many places little centers of iron-staining seem to be decomposing mica scales. Other portions of this rock are opaque, white, and distinctly granular, and are seamed with fine black lines, arranged so as to show discordant stratification. These seams, when split open, appear to be composed of blackish mica. Bluish-white veins and nests occur here also.

Marion.—In the town of Marion, T. 18, R. 11 E., Waushara county, are three low granite knobs. Two of these, Stone and Pine bluffs, are on the N. E. quarter Sec. 27, about two miles in a N. N. W. direction from the quartz-porphyry hill of the town of Seneca, Green Lake county; and the third, a larger and bolder hill, lies on the eastern border of the marsh, on Secs. 12 and 13, and stretches to some extent over the line into the town of Warren. On all of these areas the rock observed is nearly the same, a pinkish, feldspathic granite, mottled with gray and green, closely resembling the Montello granite, from which it differs, however, in having a coarser grain, a less close texture, and a marked tendency to decompose. Reddish cleavable feldspar is the principal ingredient, occurring in facets up to one-eighth and one-quarter of an inch in diameter; quartz is abundant, fine, granular, and translucent; mica is sparse, and scattered in small greenish-black blotches. Large whitish porphyritic feldspar occurs. There is no sign of any arrangement of the ingredients or of any parallel grain to the rock. No definite bedding planes were observed on any of the outcrops, though numerous crossing joint planes occur, and quite regular flat slabs are sometimes obtainable. Veins of white quartz occur. The most marked characteristic of the rock is its tendency to weather and shell off in crumbling masses. Some of the large flat surfaces are so far crumbled as to be penetrated readily by a horse's hoof. The rock from these outcrops would polish easily, but its tendency to crumble renders it less valuable than the Montello granite.

The following regarding this state is from the report on Eastern Wisconsin, by T. C. Chamberlin:

Mukwa.—The isolated outlier found in the S. E. quarter of the N. E. quarter of Sec. 26, and the N. W. quarter of the S. W. quarter of Sec. 25, town of Mukwa, Waupaca county, lies nearest the main Archæan area. This outcrop seems to have been unknown to the geologists heretofore, and came to my attention through information derived from Mr. Carr, of New London.

It consists of three large, and as many small, rounded, elongated, dome-like outliers, arranged nearly in a line trending W. 35° to 40° N., and rising near the center to a height of nearly 70 feet.

The rock consists chiefly of red feldspar, with which is associated a less quantity of quartz and a small and varying amount of a dark mineral, which was not seen in the distinct crystalline form, but which seemed to be an aggregation of minute blended blades of biotite. The crystals of feldspar are never large, seldom exceeding a quarter of an inch in length, and are usually quite minute, so that some portions, from which the dark mineral is absent, closely resemble red quartzite in appearance. The rock is intersected in various directions by veins of quartz. It is also cut into pyramidal masses by smooth, straight fissures, which are usually inclined at an angle of from 60° to 85° to the horizon. In trend these fissures constitute three groups: the first nearly north and south; the second nearly east and west; and the third northwest and southeast. There are also large irregular fissures, and occasionally points are to be observed from which an unusual number, both of the smooth and the irregular ones, seem to radiate.

FIG. 17.

PROFILE SECTION SHOWING THE RELATIONS OF THE MUKWA GRANITE.
1. Outlier of granite. 2. Potsdam sandstone. 3. Lower magnesian limestone.

The rock is very little affected by weathering, and affords an excellent building material, though the form of the blocks is unfavorable, and it is somewhat hard to dress.

No rock was found in contact with it, but about half a mile to the southeast, in the line of its trend, the lower magnesian limestone appears, into whose horizon the outcrop rises, though it lies chiefly in that of the Potsdam sandstone, as shown in the accompanying profile.

Berlin.—At Berlin, 30 miles south of the above, we next find an outstanding Archæan mass, (*a*) consisting of three large elongated domes arranged *en échelon*, bearing northeast. The rock is composed essentially of small crystals of orthoclase feldspar disseminated through a peculiar crypto-crystalline base of felsite and quartz, forming a quartz-porphyry. The crystals of feldspar are usually grayish before weathering, becoming reddish afterward. The base

a Comp. Dr. Percival's Report of 1856, p. 106.

in its unweathered state very much resembles quartzite, and is of dark grayish cast with a very slight reddish tinge, so modified by its translucency as to give to the whole what may be called a water hue. Very thin splinters may be fused before the blow-pipe with difficulty, forming a transparent glass-like bead. The effect of weathering is marked and peculiar. The color changes to a light reddish, pinkish, or grayish white, and occasionally to a bright red, while the mass becomes opaque and finely granular, and so soft as to be easily cut. There are occasionally spots, streaks, or leaves of dark material in the base, which are doubtless the portions referred to by Dr. Percival as "interlaminated hornblende and mica".

The rock is very uniform in character at all points exposed. It presents an obscure parallel structure giving rise to a somewhat definite system of cleavage, but traces of distinct bedding were not observed. The mass is traversed by extensive fissures, which are readily arranged in three groups, the predominant one of which bears northwest, and the smaller ones east of north and north of east, respectively, thus dividing the horizon into nearly equal arcs; but none seem to be dependent upon the cleavage structure of the rock.

Pine Bluff, R. 13 E.—Seventeen miles south of Berlin there rises out of the flood-plain of the Grand river a conspicuous mass of quartz-porphyry known as Pine Bluff. It ascends by steep and even precipitous acclivities to a height of 100 feet, and being entirely isolated from the surrounding elevations, and largely bare of soil and vegetation, becomes a striking object. The rock consists of white-gray and flesh-colored crystals of orthoclase and of glassy feldspar set in a very hard gray or black quartz-felsite base. The crystals of feldspar vary in size from three-tenths of an inch in length downward, but are rendered conspicuous by contrast of color. The rock is susceptible of a very high and beautiful polish, but is wrought with difficulty on account of its hardness. The dip is about 20° to the east of south. Obscure glacial striæ, still preserved, testify to its endurance. Their direction is south 45° west. The accompanying profile exhibits its relation to the Silurian formations, from which it will be seen that it rises to about the base of the Galena limestone.

FIG. 19.

NORTH AND SOUTH SECTION THROUGH PINE BLUFF.
1, Quartz-porphyry, Pine Bluff. 2. Lower magnesian limestone. 3. St. Peter sandstone. 4. Trenton limestone. 5. Galena limestone.

Marquette.—Near Marquette, a little more than 12 miles west of Pine Bluff, very similar quartz-porphyries display themselves in more considerable force, constituting a group of prominent hills. A portion of the rock is precisely identical in character with that of Pine Bluff, and the greater mass is but an unimportant variation from it, but certain portions depart from the porphyritic character, and become almost or entirely crypto-crystalline. One variety of this kind very closely resembles the more homogeneous of the red Huronian quartzites, and another is a compact, close-textured rock, usually of dark color, but sometimes greenish. Neither of these varieties occupies exclusively any one horizon, but the quartzite-like variety is found in the more southern outcrops, the last-mentioned kind immediately north of that, the darker porphyries next, and the coarser, lighter-colored ones in the most northerly exposures.

The bedding is very obscure, but the laminations of certain portions and belts of particular varieties of rock show the strike to be northeastward. The dip is made out with much less certainty, but appears to be to the northward, and to vary from 15° to 45°.

Though the Berlin porphyry differs from that of Pine Bluff and of Marquette in the absence of glassy feldspar, yet the close lithological alliance of the three is very evident, and they doubtless all belong to the same group of the Archæan series. The general strike of these formations, projected westward, encounters several similar outliers that are described in Professor Irving's report, and still farther southwest he has found similar quartz-porphyry overlying the Baraboo quartzite. There seems to be sufficient reason for regarding the latter as Huronian, so that the porphyries must be regarded as a newer portion of that formation.

All of these masses present the rounded contour of glaciated surfaces, and still bear the glacial groovings, and, in some cases, even remnant polished spots, and from all these trains of porphyry bowlders stretch away in the direction of the striæ.

Portland and Waterloo.—Thirty-five miles south of Pine Bluff, over an area entirely covered by Paleozoic rocks, some as recent as the Galena, we again encounter the Archæan rocks in the form of the quartzites of Portland and Waterloo.

The outcrops in the town of Portland are several in number. The most southwesterly is an oval island lying mostly in the S. E. quarter of Sec. 33, and is entirely surrounded by lowland or marsh. The outcrop attains but a slight elevation, and its rounded contour shows abundant evidence of the glacial agencies that have swept over it. Not only striæ, but deep, broad furrows, show the direction of movement to have been S. 15° to 20° W. Bowlders appear in great force upon the protected side of the island and doubtless thickly underlie the deep morass in that direction, as they appear again upon the hills beyond. Directly to the east, in Sec. 34, there is a slight exposure near the base of a somewhat elevated north and south ridge, of which it doubtless forms the nucleus, if not the chief portion.

Less than 1 mile north of these outcrops the quartzite again discovers itself on the brow and west flank of the ridge facing Waterloo creek. There is no evidence that any later formation overlies the quartzite between

this and the two preceding outcrops, and so the three will be found mapped as constituting a single Archæan area. A short distance farther to the north (N. W. quarter Sec. 27) the quartzite rises in the midst of a marsh-like lake, constituting Rocky island. It may be characterized as a low dome covered with unsymmetrical *roches moutonées*.

About 2 miles southeast, at the foot of a hill, and on the edge of a marsh, occurs a low and limited outcrop (Sec. 35, S. E. quarter, and Sec. 36, S. W. quarter). One-half mile to the northeast, across a marsh, there occurs another exposure, similarly situated in a southern extremity of a north and south ridge, and about the same distance to the southwest still another one may be seen, the three lying nearly in a straight line and separated by marshes. They are regarded as being projecting knobs of a common area, and are so mapped. Between these and the three outcrops first mentioned, as also between both these and Rocky island, later formations intervene, so that they must be regarded as forming three distinct, though closely associated, surface areas.

MINNESOTA.

[Compiled mainly from notes by Professor N. H. Winchell.]

CRYSTALLINE SILICEOUS ROCKS.

More than half of the state is underlaid by that general class of rocks—the crystalline—to which granite belongs, and consequently the state has almost every variety of crystalline rock. These rocks also exhibit all degrees of durability and value for building purposes. The granular crystalline rocks are generally very durable; and, whenever they are exposed above the drift, can be wrought with profit and with the most satisfactory results. While in the northern part of the state there are large exposures of very fine light-colored granites, beyond the limits of settlements and roads, and particularly at lake Saganaga, those in the valleys of the Mississippi and Minnesota rivers are of more special and immediate interest. These have been somewhat quarried, and their products as building materials can be seen in some of the principal buildings in various parts of the state, as well as in cities outside the state. The gray granite that is quarried at Sauk Rapids, and which generally is seen in Stearns county, consists largely of quartz embraced in a matrix of orthoclase, with but a small proportion of mica or chlorite. Hence it is hard and very durable. The dark mica is biotite, and there is but occasionally a grain of hornblende. This last sometimes prevails largely over all the other minerals in small areas or veins, making a very dark-colored and also generally a coarser-grained rock. There is also occasionally a grain of triclinic feldspar and of magnetite, and some minute crystals of pyrite. These minerals have a relative hardness when expressed on a scale of 10 as follows, 7 being the hardness of an ordinary knife-blade:

Quartz	7
Triclinic feldspar	6 to 7
Orthoclase	6 to 6½
Hornblende	5 to 6
Biotite	2½ to 3
Muscovite	2 to 2½
Chlorite	1 to 2

About one-half of the whole rock is made up of quartz, and two-thirds of the remainder of orthoclase. About one-half of the rest is triclinic feldspar, and the residue is divided between the other minerals, biotite predominating. It is plain to see that such an assemblage of minerals constitutes a very firm rock, and one that is rather hard to dress, but when once cut to form and placed in a building it will endure indefinitely. The biotite, muscovite, and chlorite serve to make the granites easy to cut and to quarry; and particularly when they lie in sheets or in indistinct belts through the rock, giving it a faintly striped aspect, constituting a gneiss, the rock can be got out easily in large, long slabs or blocks. When these are evenly scattered through the whole rock, the rock is simply softened, and in quarrying the fracture will have to be more completely guided by the plug and feather. For taking a polish the absence of these soft minerals enhances the value of the rock. The durability of the Sauk Rapids granite was tested at Washington under direction of the chief of engineers, and was found capable of sustaining a crushing pressure of from 15,000 to 17,000 pounds per square inch. A quarry at Sauk Rapids has been longest known of all the granite quarries in the state, but it is not now (1880) as vigorously operated as those at Watab or at East Saint Cloud. Blocks 12 by 3 by 1½ feet thick and 10 by 4½ feet by 1 foot thick have been quarried, and blocks as large as 26 by 22 by 5 feet thick might be moved if desired. The material is now used mainly for monuments, formerly also for building and for bridge construction. Among the principal structures in which this stone has been used are the capitol buildings at Des Moines, Iowa (trimmings); the city hall, Minneapolis; Nichols & Dean block, Saint Paul.

The color of this granite, being a neutral gray, makes it suitable for a wide range of architecture. Light-colored and reddish granites are found at Watab, a few miles north of Sauk Rapids, and also in a few places near Saint Cloud and Rockville.

At Watab there are three principal varieties of different textures and colors, each being quarried from a different opening, so that the stone in each quarry is uniform as to texture and color. The red is located to the north of the gray granite, and is separated from it by a distinct line, a change being abrupt (within 6 inches). Although the

quarry was opened some years ago, it was not operated during 1880. This stone is being used in the construction of the bridge over the Missouri river at Bismarck, and about 7,000 cubic yards will be used for this purpose. The following is a report on this stone, by Captain Edward Maguire, U. S. A., chief engineer, department of Dakota:

Two kinds of granite were used by the Northern Pacific Railroad Company in the masonry work on their bridge at Bismarck; first, a light-colored and reddish granite, found at Watab, a few miles north of Sauk Rapids, Minnesota. The quality of this stone was good, but its use was abandoned on account of the cost of quarrying it. The bed is very much cut up by seams, and in order to obtain the requisite sized blocks it was necessary to quarry about ten to one. The largest blocks that have been quarried are 6 by 4 by 2 feet thick; some blocks 30 by 12 by 5 feet thick have been moved, but were cut up for transportation. The texture is rather coarse and uniformly crystalline.

Captain Maguire reports an examination of gray granite from the Rock Island quarry, situated in a prairie about 4 miles from Saint Cloud, and there are at least 4 and probably 10 acres of this gray granite from which blocks of any size or shape may be quarried.

While the granites of Stearns county are massive or non-gneissic, those of the Minnesota valley are almost invariably of a laminated structure, and of a reddish color. One of the principal exceptions occurs in the large granite outcrop near the foot of Big Stone lake. The Minnesota Valley granites differ from the Saint Cloud granite, also, in being softer, on account of having less quartz and more of the cleavable minerals, orthoclase and mica. They are also easy to quarry, but they have not been much worked yet. Some of the recent cuts in the red granite near Montevideo, by the grading for the railroad, show a very superior variety of rather coarse grained red granite, which cannot fail ultimately to be in great demand. There are great stoneless tracts of prairie lying south and west of the upper Minnesota Valley region, and extend from near New Ulm to the foot of Big Stone lake.

The so-called granite of Duluth belongs to a very different class of rocks, and is more properly styled "gabbro", a new term derived from Italy, and applied to an igneous rock consisting of the triclinic feldspar, labradorite, augite, and a magnetic oxide of iron containing titanium. These minerals are all softer than quartz, which is wholly absent from the Duluth rock, but which makes up so large a part of the Saint Cloud granite. It is strange, therefore, that the Duluth rock should have been so generally regarded as harder than real granite, and particularly as harder than the Saint Cloud granite. The mineral augite, which makes up generally less than one-fourth of the whole, has a hardness of from 5 to 6 on the scale of 10, and labradorite is but little more. When this rock begins to decay, the augite changes first, making a greenish, soft mineral like chlorite, and this change sometimes is found to have gone on to a great depth in the rock without any change being seen in the other minerals. In such cases, while the rock is not much injured for building purposes, it is more easily quarried and dressed. While taken in a mass this Duluth rock may correctly be said to be softer than the Saint Cloud granite; it is tough and firm, being perfectly crystalline and compact. The magnetite in this rock sometimes becomes so abundant that it spoils it for building, and even becomes an iron ore, and has attracted attention as such. The iron ore reported some years ago at Duluth, at Herman, a few miles west of Duluth, and at Iron lake, north of Grand Marais, is all of this variety, and in some cases it is pure and valuable; but it is damaged by the presence of the titanium. The titanium is not so much a damage to the iron as an impediment in the reduction of the ore. At Duluth this rock has been used in some foundations, but the difficulty of dressing it, as well as of quarrying, has prevented its acceptance as a general building material. Its strength is about 17,000 pounds per square inch.

The gabbro quarry at Duluth, Saint Louis county, is from a mountain-like range extending northeast from Rice's point at Duluth. It is discussed in geological reports of Minnesota for 1879 and 1880, it being No. 1 of the *Minnesota Geological Survey* series. The rock is of the age called Cupriferous in Minnesota, the equivalent of the Potsdam in other portions of the country. Blocks of as large a size as could be handled might be quarried here. The mass of rock is but little jointed; its texture is a uniform crystalline, and it has been used thus far chiefly in trimmings for buildings and for rough walls at Duluth, and some for trimmings and steps at Saint Paul.

A trap from this formation has been quarried by the United States government to be used in the construction of breakwaters at Duluth. The stone is roughly and basaltically bedded, and it may be called imperfectly basaltic; its texture is uniformly crystalline; it is No. 53 of the *Minnesota Geological Survey*, report of 1880. It is a basaltified layer of igneous rock intercalated between sedimentary beds. There is an excavation made in trap-rock for the site of a new school-house in Duluth, and the stone is put in the foundation and basement of that building. It is seen in outcrop conspicuously in front of the engine-house in that city, and extends northeastwardly in the form of a low hill range or ridge; it seems to be that which forms the falls of Kinichiguaguag creek, near Duluth; it is No. 43 of the *Minnesota Geological Survey*, report of 1880. This stone is massive, close, and fine in texture, sometimes finely porphyritic; the mass of rock is distantly jointed.

No. 42 of the reports of the *Minnesota Geological Survey* of 1880 is not quarried; it is so situated in many places near Duluth that it might be quarried with profit where a stone easier wrought than No. 1 of the series is desired. In the weather it has naturally assumed numerous conchoidal-fracture planes. These make it difficult to get blocks of a given size and shape, since the pieces break in dressing along the old fractures, which are not parallel nor perpendicular, but cross at acute angles in all directions, like some massive shale in disintegrating. This rock is believed to be derived from the red shale of the Cupriferous or Potsdam series by the semi-fusion incident

to the igneous ejections; other stages of crystallization, even to red granite and other less changed conditions as a perfect red shale, can be seen along the shore at points farther down the lake and at Duluth. Within the limits of Duluth it can be quarried as red granite; it is in the hill range on the slope facing the bay, and at the quarry at Rice's point is associated with No. 1.

In the hills back of Duluth it changes suddenly to a red granite, supposed to be derived from the fusion and metamorphism of the Fond du Lac red shales and sandstones when the igneous rock was poured out through and over them. These two kinds of rock (red syenite and gabbro) are closely intermixed in patches, sometimes of large area, and extend thus all the way to the northern boundary-line of the state, the red rock showing various stages of metamorphism and crystalline condition. The red granite in some places is very coarse grained and beautiful, something like Scotch granite, and in other places it is very fine grained and compact, as at Duluth. It contains quartz, generally in large quantity, red orthoclase, and green hornblende or chlorite.

At East Saint Cloud, Sherburne county, a massive Archæan granite is quarried for general building purposes and used chiefly at Saint Paul, Milwaukee, and Minneapolis. The trimmings of the United States custom-house at Saint Paul are of this material. There are three varieties, differing somewhat in texture and color. The one most used and highly prized is of a fine-grained uniform texture and gray color. It is often slightly gneissic or laminated in structure, and works more easily than the others; it is probably not so durable nor firm under pressure. The second variety is red, and contains a good deal of quartz, but takes a finer polish. It was not quarried during 1880 so much as in former years, chiefly because the plant of the establishment is situated some little distance from the favorable exposures, but there is abundant opportunity in the neighborhood for working this red granite. The other variety is not now quarried, but large quantities of it were formerly taken out and used chiefly as trimmings in the custom-house at Saint Paul, where, however, stone of both the other kinds is also to be seen. It has outwardly, and especially when chiseled for construction, as in the custom-house, very much the aspect of the gabbro quarried at Duluth, and might be mistaken for that stone on a casual examination. It has the reputation among the quarrymen of being very hard, and is said to require more frequent sharpening of the tools than either of the other varieties, which circumstance has prevented its extensive use.

The East Saint Cloud granite, when used for paving, is dressed roughly in blocks of about 10 by 3 by 5 inches deep. Blocks 50 by 12 by 6 feet thick have been moved; the size of blocks which may be quarried is only limited by the ability to handle; blocks 20 by 6 feet and as long as 60 feet may be quarried if desired.

There is a very firm syenitic granite near Motley, on the Northern Pacific railroad, which is similar in outward appearance to the Saint Cloud granite, and will furnish stone for a large tract of stoneless country west of that point, this being the most westerly outcrop of rock known on the line of that railroad within the state.

At Beaver Bay, Lake county, a red granitized shale of Cupriferous or Potsdam formation (metamorphic group, and is one of the conditions of the metamorphosed sedimentary rocks of the Cupriferous series) is somewhat quarried for dock construction. The ledge lies conveniently near the docks, in the construction of which this stone was used. The rock was taken out in the north side of the bluffs facing the bay. The material is rather fine in texture. The structure of the rock is somewhat basaltified, yet jointed transversely.

Four miles below Beaver Bay, on an island in lake Superior, a so-called red granite of the Cupriferous series is found, but has not as yet been quarried. It is No. 811 of the *Minnesota Geological Survey* reports. It is believed to be derived from some of the original sedimentary portions of the Cupriferous beds, and would make a very good building material if in the course of the settlement of the country it should become desired. The rock is uniformly crystalline in texture; at most points it is little jointed, but it is occasionally imperfectly basaltic.

There is a labradorite rock of the Cupriferous series exposed at the lake shore, 2½ or 3 miles east of Beaver Bay, which may be used for ornamental purposes as well as for general construction. The supply is abundant and easily accessible. The rock seems to graduate into the gabbro exposed at Rice's point. The texture of the stone is uniform and coarsely crystalline; it is bedded in some places and in others a solid mass.

At the lake shore, near the mouth of Baptism river, Lake county, there is a porphyritic felsite of the Cupriferous series; it is Nos. 138 and 139 of the Minnesota geological report for 1880. The stone is porphyritic, with quartz and perhaps adularia, and it is indistinctly laminated and basaltic in structure. The rock is also exposed 2 miles west of the great palisades, on the north shore of lake Superior, Lake county; it may possibly be used for ornamental purposes, and it illustrates the gradual change from the red shales of the sedimentary beds of the Cupriferous to crystalline rock. (See proceedings of the American Association for the Advancement of Science for 1880–'81.) In this locality there is also a metamorphosed shale (with adularia) of the Cupriferous series; it is No. 140 of the *Minnesota Geological Survey*. Specimens of the stone in the National Museum are a brick-red in color; it is usually banded and porphyritic, with quartz and translucent grains that seem to be adularia.

On Encampment island, Lake county, a hyperyte rock of the igneous group of the Cupriferous series is found; it has not been quarried for building purposes, but is interesting from a scientific point of view. In texture it is uniform and coarsely crystalline, and is irregularly jointed and bedded. On the shore of lake Superior, at Two Harbor bay, in Lake county, there is a dark, heavy, uniformly fine-grained rock, probably of the sedimentary group of the Cupriferous. It has not yet been quarried, but has a scientific interest in connection with the investigation of the crystalline rocks of this formation, as its outward characters have not been sufficiently distinct to indicate its

affinities so as to warrant its being classed in either the igneous or metamorphic group of the Cupriferous. In the Report of the *Minnesota Geological Survey* for 1880 it is placed in the sedimentary rocks (metamorphosed), but this point is not well established. With it many comparisons have been made, and references in field-books, whenever it has been seen to occur, or where a rock like it has been met with, making it a sort of datum for the mapping geographically of rocks in other places.

A trap of the igneous group of the Cupriferous is quarried at Taylor's Falls, Chisago county, and used in the construction of foundations and rough walls at Taylor's Falls. The walls of several business blocks at this place are constructed of this stone. The color is dark, almost black, and as to the texture it seems to be made of pyroxene crystals embracing the other minerals, these causing a spotted exterior; otherwise the texture is uniform. This rock, from its proximity to Minneapolis and Saint Paul, is of economic importance because of its adaptability for paving blocks, for which purpose it would supply a most durable material. It may be described as tough rather than hard. It is the most southerly known exposure of the Cupriferous in the state, though in Wisconsin a similar rock outcrops a few miles farther south, near the Saint Croix river. Some interesting copper mining has been excited at this point by the discovery of the native copper in the rock and along some of the ravines. It is No. 820 of the *Minnesota Geological Survey;* the rock seems to have the characteristics ascribed to melaphyre by Pumpelly.

SANDSTONES.

The red quartzite at New Ulm, which also is seen in Cottonwood, Watonwan, Rock, and Pipe Stone counties, is sparingly used for a building stone at points contiguous, and one or two car-loads are known to have been shipped to Minneapolis. It is the hardest stone in the state, or in the United States, probably, that can be said to have been used for building. It consists almost wholly of quartz, the red color being due to iron oxide, which is disseminated among the grains, but does not enter them. As a layer embraced in this rock the material known as "pipestone" or catlinite is found in Pipe Stone county and other places in southwestern Minnesota. This rock it is very difficult and costly to dress into dimension blocks, but it is indestructible when once placed in a wall.

There is a quarry of the red quartzite in Courtland township, Nicollet county, near New Ulm, operated for ordinary building purposes and bridge construction, used at New Ulm and surrounding country. It was used in the construction of Sommer's block and the residence of Mr. Frank Erd, at New Ulm. The stone varies somewhat as to texture, some being loose-grained and sandy, and some firm, hard, and uniform. It is evenly-bedded in courses varying from half an inch to 4 feet in thickness; the joints and water-cracks are not distinct, but rather frequent. There is but little systematic quarrying done at this place; quarries are contiguous, and exhibit the same kind of rock. Some of the beds are shaly, and the dip about 15° toward the north-northwest. As compared with rocks at Sioux Falls, in Dakota, the opportunities for quarrying are greater here and the stone is much more easily wrought, owing to the fact that the beds are finer and softer, though it is probable that if it were to be deeply excavated it would be found to be firm and of a purplish color within; but at Sioux Falls a greater area of stoneless country surrounding the quarry will create a greater demand than ever will be felt at New Ulm.

Next in ascending order, as building materials come the sandstones proper, if we omit the black argillyte or roofing slates and their associates seen at Thompson, which will be treated under "Roofing slate". The red sandstones at Fond du Lac are probably the most valuable deposit, taken on all accounts, that the state possesses as a building stone of that kind. They are of the same formation as the New Ulm quartzite, but were less hardened at the time of their upheaval. They lie tilted toward the south or southeast, and are associated with and overlie a vast thickness of soft red shale, which passes sometimes to a shaly red conglomerate, the same that in other places about lake Superior is in contact with the igneous rocks, and becomes copper-bearing. This red sandstone is well known in Milwaukee, Chicago, and Detroit. The quarries in it farther east furnished the red sand-rock used in the Milwaukee court-house, and a great many brownstone fronts in that city and in Chicago were obtained from it. It was formerly quarried on Isle Royale, and sold in Detroit as "Isle Royale brownstone". While it consists almost entirely of quartz, the grains are not so firmly cemented or united as to render it objectionably hard. Its grain, color, and texture vary slightly. On Isle Royale, when quarried, it is fine-grained and rather brittle, being more highly metamorphosed than at Fond du Lac. At some points it has a mottling of red and gray, or even of green, as at Sault Ste. Marie, at the eastern end of lake Superior, where the ship-canal is cut in it and largely built of it. In some places it is so loosely cemented as to crumble and to be rendered useless for building, and in others it contains rounded quartz-pebbles of a nearly white color, or becomes wholly conglomeratic. At Fond du Lac some of all these features can be seen, but there is still at that place a great abundance of fine stone of the best quality. This great formation forms the southern rock barrier of lake Superior, almost without interruption, from Duluth to Sault Ste. Marie, but it is not always of so dark a color as it is at Fond du Lac. The famed "pictured rocks" of the south shore are formed of it, and the Apostle islands are caused by remnants of it that withstood the erosion of the glacial forces. Its strength, as tested at Washington, proved to be from 4,000 to 5,000 pounds per square inch. Several business blocks have been made from it in Duluth, and the new Westminster church at Minneapolis is being constructed of it. This formation is seen not only at Fond du Lac, but (probably) at Pokegama falls, on the Upper Mississippi, and in the base of the bluffs at Winona, but the most favorable and promising points for quarrying it are at Fond du Lac.

The principal quarry at Fond du Lac has been mainly engaged in getting out and shipping stone in the rough, but little being dressed at the quarry. The rock has in some of its heavy bedding stripes of light sand-rock and light spots in some of the brown. Sometimes scattered quartz-pebbles are seen in the light rock of the size of a pea, or even a hen's egg, but not much of it is conglomeratic. Lumps of red shale from 2 to 5 inches in diameter occur in belts coincident with the direction of the bedding. The bedding is even, in courses varying from 4 inches to 2 feet in thickness; the joints are distinct. The stone is used for general building purposes, chiefly at Minneapolis, Saint Paul, Brainerd, Duluth, and Fargo, Dakota, and Superior, Wisconsin. Among the buildings in the construction of which this stone was used are the Clark & Hunter block of Duluth, the Westminster Presbyterian church at Minneapolis, and some of the railroad buildings at Brainerd. There is a quarry on Missouri creek near Fond du Lac, the product of which is wholly shipped to Winnipeg for use by a contracting builder of that city. The Manitoba college is trimmed with stone from this latter quarry.

The freestone at Hinckley is probably not of the same formation, but pertains to a higher horizon—the Saint Croix. It is exposed on the banks of the stream passing through the village and at points farther down. As a building stone it is considerably lighter colored, or more nearly that of the Kasota stone, and more easily wrought than the Fond du Lac stone. It is in even, heavy beds, and can be easily got out. It is as firm and as desirable for all purposes of architecture to which it is adapted as the Cleveland freestone which is so largely used. It can be dressed more cheaply than the Fond du Lac stone and can be cut into ornamental forms for capping or for columns. Its compressive strength has not been tested yet.

The stone from this quarry is evenly bedded in courses varying from 6 to 18 inches thick; there are but few joints. The Saint Paul and Duluth Railroad Company operates the principal quarry at Hinckley, Pine county, for bridge construction, and the stone has lately been put into the foundations for the high bridges and trestle-work on that railroad along the dalles of the Saint Louis river. It is the only rock known between White Bear lake and the slate region of Thompson, which begins near Goose Lake station.

At Dresbach, on the Mississippi river and the Chicago, Milwaukee, and Saint Paul railroad, in Winona county, sand-rock of the Saint Croix, which is the lowest sand-rock in the geological scale of Minnesota, is occasionally quarried for ordinary building purposes and shipped to Minneapolis and Saint Paul. The stone promises considerable usefulness in the future, though as yet is but little quarried. The rock has been quarried to a limited extent also at Dakota, 2 miles north of Dresbach, and much attention has been attracted to the material at both these places, as it nearly resembles the Berea sandstone of Ohio, which is now largely used in first-class buildings in Saint Paul and Minneapolis, it being transported there by rail at considerable expense. The development of this industry in Minnesota, so far as Dresbach and Dakota are concerned, is due to the direct and immediate efforts and recommendations of the geological survey of the state in calling attention to it during 1880. There is an unlimited supply of this stone in the bluffs of the Mississippi river, but its best color is found only near the level of the water of the river. The stone is of a fine texture, and varies from a light gray to buff in color, some of it showing even and distinct stratification, and some being massive; it is evenly and horizontally bedded in courses from 3 inches to 8 feet thick. Blocks 8 by 4 by 4 feet have been quarried; and blocks as large as 20 by 8 by 6 feet, or as large as could be conveniently handled, might be quarried.

The other sandstones of nearly the same geological horizon are not very good for building, being too friable. They are exposed in the bluffs of the Upper Mississippi below Hastings, and of the Saint Croix below and above Taylor's Falls, where they have been put into one or two business blocks. They are of rather coarse grain and friable on first quarrying, but the weather operates to harden them somewhat in the course of a few months. When they are finer, and mingled with an aluminous sediment, they are also somewhat magnesian. They are then fit for rough walls, but for first-class architecture they cannot be used, owing to the thinness of the layer and the general incoherency of the grain. Still in some towns this kind of stone is employed exclusively for the general home demand, as at Hokah and at Lake City.

The Jordan sandstone of the geological horizon of that name in the Lower Minnesota valley is very much like that at Taylor's Falls, but is in a much higher geological horizon. It has been used considerably at Jordan, and serves a good purpose for general building, but it cannot be recommended for first-class structures. It is of a light color, but stained and clouded, or striped by a yellowish or rusty iron cement. It is likely that the darker-colored beds of this stone will be found most durable. This rock appears in the Minnesota valley, forming islands and rapids near Carver. If it were to be wrought along the Minnesota river, where it has been for a long time subject to the rusting and cementing action of the waters of the river at periods of flood, it would be found much harder and more valuable. The bedding is even, and in courses varying from 2 inches to 2 feet in thickness, jointing irregular, the texture fine, sometimes friable, and there are signs of irregular stratification. There are two principal varieties in the quarry; that from the bottom is of light gray or bluish color; that from the uppermost 16 feet of the ledge is the stone which has been hitherto used exclusively in building. The gray is very similar in appearance to the Berea, Ohio, sandstone. Among the buildings in the construction of which this stone has been used are the Foss & Wells flouring-mills, at Jordan, and the City mills and the American house (first story), at the same place.

Ordinarily the Saint Peter formation is very friable, and particularly where it is freshly exposed, or is being continually reduced by the action of winds or by running water. But when the river water occasionally or

periodically overflows it, the repeated evaporation of the water leaves a deposit of iron-rust, which on entering among the loose grains of the rock soon so firmly cements them, especially on being thoroughly dried, as to make a useful building stone. Such a process goes on in all low grounds where water evaporates without free escape, and generally causes a rustiness on the mud or on the dead twigs or roots of the place, or even goes so far as to form a bog-iron ore. If a rock be exposed there it becomes more or less rusted, and if before incoherent it becomes firm. Although stone quarried from this formation has been put into the piers of the bridge at Fort Snelling in large blocks, it can hardly be said to constitute a reliable supply of good stone for the cities of Saint Paul and Minneapolis. When evenly and thoroughly cemented by the iron-rust it will form a durable rock, but its liability to inequalities in the hardness of the mass, to variations of color, and to the exhaustion of the supply will operate against its extensive use.

At Mendota, Dakota county, sandstone rock of the Saint Peter subdivision of the Lower Silurian is quarried for bridge construction on the Chicago, Milwaukee, and Saint Paul railroad. The piers of the bridge over the Mississippi river at Fort Snelling are built of this stone. This stone, which serves well for heavy masonry, and could be cut for ornamental work in structures, shows the effect of the waters of the Mississippi river in hardening the very friable white sand-rock, known as the Saint Peter sandstone. The outcrop in which the quarry is situated is in the bottom land of the river and rises but a few feet above low water. It is annually overflowed and has been for an unknown period evidently, at least since the glacial epoch, and it is to this fact that the cementation of the siliceous grains is due, the evaporation of the water as summer advances leaving a sort of iron cement. It is also probable that the cement is partly siliceous, since the waters of the river are slightly alkaline, and thus might dissolve some of the silica of the rock, depositing it again as a cement. No other such effect on the Saint Peter formation is known but in the valley of the Minnesota river. Above this place, the Shakopee formation is thus affected at Kasota, the Jordan at Van Osser's creek, near Louisville, and the Saint Lawrence at Jessen Land; in all cases the change of character being due to the interpenetration of iron oxide on the evaporation of the water of the river.

The stone used at and below Austin, taken from the low banks of the Cedar river, seems to belong to the Upper Devonian. It is believed to lie conformably over the Devonian limestones that are seen in outcrop farther down the river, a few miles south of the state line in Iowa. The stone itself in its natural color is of a light blue, and that color shows on most of the quarried blocks about the heart of the bedding, and on deep quarrying it would doubtless show only a blue color. Yet the stone as now used is very generally of a buff color to the depth of from half an inch to 3 inches, depending on the amount of weathering and oxidation. The thinner beds are altogether changed to that color. The texture of the stone is close, and the grain is homogeneous. Some large slabs and blocks are sawed for bases to tombstones, and worked down to a very smooth surface. It is more safely sawed to any desired dimension than cut or broken, yet it is not in the least crystalline. Its aspect at a distance is that of a fine-grained sandstone, yet it contains no apparent grit. It is so soft that it can be cut without difficulty, appearing much like an unusually indurated blue shale, but it hardens in use and serves a useful purpose in common buildings, but cannot be depended on for first-class structures. Its argillaceous composition will ultimately cause it to crumble, especially if it be subjected to frequent changes of moisture and dryness.

At several points in the banks of the Minnesota river between New Ulm and Mankato a hard, siliceous sandstone of Cretaceous age is exposed, which has supplied some very good building material. The layers are about 4 inches in thickness, and are tough and firm. They are associated with alternating layers of a friable sandstone, which aids in their extraction. These beds are sometimes so coarse as to justify their being designated as conglomeratic. The stone is very durable as a building material, but the toughness and hardness of the texture and the thinness of the beds, make it more suitable for flagging than for building. It is typically exposed on the land of William Fritz, Sec. 16, T. 109, R. 29, in Nicollet county and other places near.

LIMESTONES.

The lowest limestones in the geological scale are those seen in the bluffs of the Mississippi river and in the Saint Croix valley. They generally form the tops of the bluffs, and cause the precipitous portions, the sloping talus being taken up with one or more of the sandstones above mentioned. These limestone beds present a varied lithology, and cause some very interesting topographical features. As a building stone they are wrought at all points where there is a demand (except Lake city), between Stillwater and Winona, along the Mississippi valley on the Minnesota side, and also at several places farther west, as at Caledonia, in Houston county, Lanesborough and Rushford, in Fillmore county, and at points in Winona county. The material they supply is in general a magnesian limestone of a light buff color, a firm but sometimes vesicular or porous texture, and often having a considerable proportion of quartz. An analysis of a sample from Sugar Loaf, Winona, gave the following result:

	Per cent.
Insoluble (mainly quartz)	24.21
Ferric and aluminic oxides	3.32
Calcium sulphate	4.32
Calcium carbonate	47.11
Magnesium carbonate	20.67
Total	99.72

Showing that nearly one-fourth of the whole consists of quartz. In other places would be found less quartz; and this is particularly the case at Frontenac, where the rock is so even-grained and so free from quartz that it is sawed by machinery into such slabs or blocks as are wanted. The quarries at Winona and Red Wing are in beds of this stone that are quite similar as to texture, being open and loose, or having small scattered cavities. In these cavities are sometimes linings of drusy quartz crystals. In other beds this quartz is gathered instead into nodules of chert or flint, which, although having a white exterior, are hard, and often gray within. This is the condition of the quartz in the stone at Frontenac, but these flint lumps are not common there. In other places whole beds are cherty and worthless for a building stone. This formation, which probably at the present time furnishes more stone than any other in the state, is destined to be still further used for the same purpose, as it is most favorably situated at its exposures both for excavation and for shipment and transportation, and supplies one of the best materials for all purposes of architecture. It varies from a light buff to a light drab color. When placed in a structure it has a lively and cheerful expression. At Frontenac it is cut into ornamental forms with comparative ease, and the same kind of beds as those at that place are found throughout the southeastern part of Goodhue county and the northern portion, at least, of Wabasha. It is but slightly changed after many years exposure to atmospheric influences; indeed, it has not been in use long enough yet in the state to show any change whatever by lapse of time, although it is in some of the oldest buildings of the state. The homogeneity of its composition and texture, as at Frontenac, and the regularity and thickness of its bedding, are qualities that enable it to supply slabs and blocks of any desired dimensions. Its resistance to pressure, amounting to 5,000 to 7,000 pounds per square inch, is sufficient to warrant its use in all ordinary structures, while for door moldings and caps, for sills and water-tables, and for all trimmings to brick structures, it is unsurpassed.

The limestone of the Saint Lawrence horizon, the lower portion of the great magnesian limestone of the west, in the vicinity of Stillwater lake, is often somewhat siliceous, and the determinations made at the National Museum for this report show it to be properly sometimes a dolomite and sometimes a siliceous dolomite. A chemical analysis of the samples of the stone usually show a high percentage of magnesia, considerable iron, and siliceous matter. At a quarry of this limestone at Stillwater, on lake Saint Croix, and on the Saint Paul and Duluth railroad, the ledge is about 45 feet thick, and extends still farther below. It alternates in bands of compact and of vesicular rock from 3 to 6 feet each, and there is about an equal amount of each kind, all lying in horizontal courses. The coarse and vesicular dolomite is used for the heaviest masonry, such as bridge construction; it is in beds of from 18 to 30 inches thick, and is more firm and durable than either of the other varieties. One variety is called "sand-rock" by the quarrymen, though plainly containing very little, if any, quartz sand, and has a uniform and granular texture. The other principal variety is most useful for general purposes; it is especially sought for and adapted to use for sills, water-tables, and caps, making a stone which is fine and uniform in texture, and of uniformly light buff color. It yields a good surface under the hammer and chisel, and is employed for bases and tombstones; it is also used for ashlar, pilasters, and copings. The use of this stone thus far has been only local, and the following are some of the buildings in the construction of which it has been employed: The state prison, public school-houses, one Catholic church, store building of Mr. Isaac Staples, Universalist church, and the Fayette-Marsh block, all in Stillwater.

The Saint Lawrence limestone is quarried at Stockton, Winona county, for bridge construction and foundations, and employed in the railroad work along the Winona and Saint Peter railroad and in the towns on that road. The stone was used in the construction of the railroad round-house at Winona. In texture it is generally uniform, but sometimes vesicular, cherty, and geodic; in color it is buff; it is a dolomite containing a small percentage of iron. The stone is evenly and horizontally bedded in courses usually from 9 to 25 inches. There is a coarse concretionary (apparently brecciated) condition sometimes seen in this formation from 25 to 100 feet in thickness, which has to be entirely thrown away or used as filling by the railroad. A concretionary condition occurs in isolated masses and nodules, and does not extend far horizontally; at least it is not always present at any given horizon. The quarry is operated by the Chicago and Northwestern railroad, and most of the best stone is used in bridge and other construction. The Saint Lawrence is quarried also at Winona for general building purposes and flagging for local use; some of it is burned for lime and shipped to Minneapolis and Saint Paul. The location of the principal quarry is on an eminence known as Sugar Loaf hill. The stone has been used in the construction of a Congregational church, an Episcopal church, and the jail at Winona. It is usually fine and uniform in texture, but some of it is porous and contains quartz lumps. The color is usually buff; it is evenly and horizontally bedded in courses from 4 inches to 3 feet in thickness; there are signs of irregular stratification. Blocks 8 by 6 by 2½ feet thick have been quarried, and blocks of any size that can be handled may be quarried. The perpendicular joints are usually from 10 to 20 feet apart. The magnesian limestones of Minnesota are generally buff in color—at least the dolomites are—the only variation from buff being in some of the aluminous parts of the Trenton, when the term "dirty drab" might be used, perhaps.

The Saint Lawrence limestone quarried at Red Wing, Goodhue county, is used locally for general building purposes and for quicklime. It was employed in the construction of Christ church, the Red Wing and Diamond flouring-mills, the first stories of the Saint James hotel, and the residence of Dr. A. B. Hawley, all at Red Wing. It is a dolomite, fine in texture; some is vesicular and some compact, and the color varies from buff to light buff. It is

evenly and horizontally bedded in courses varying from 4 inches to 3 feet. Blocks 8 by 6 by 2½ feet in thickness have been quarried, and blocks of any size that can conveniently be handled may be quarried. The quarries at Red Wing do not differ much in the manner and kind of stratification, or in the quality of stone produced, from those at Stillwater.

At Frontenac, in Goodhue county, this formation is quarried for general building purposes, and used to some extent also for bases and tombstones. It was used in the construction of Barney's block, in Saint Paul. It is here also a dolomite of medium fine and very vesicular texture, buff in color, and evenly and horizontally bedded in layers often as thick as 5½ feet; it is jointed at irregular intervals. The dimensions of the largest block that has been quarried are 11 by 7 by 5½ feet, weighing 18 tons; this is about as large as can be obtained from the quarry. Saws and rubbing-beds are used in dressing this stone at the quarry. This stone is considered one of the best in the state; it is seen in some large first-class buildings in both Minneapolis and Saint Paul, and the front of a large block in Minneapolis is being constructed of it by Mr. H. D. Wood.

That limestone formation (Shakopee) which is wrought at Mankato, Ottawa, Kasota, Shakopee, and Saint Peter lies about 100 feet higher in the geological scale than the last mentioned, but it is in nearly all places where wrought of nearly the same character and as useful for all purposes, though it does not present the evenness of texture and freedom from quartz seen in the Frontenac stone. At Kasota the river has at some early time stained it in the same way that it has the Saint Peter sandstone, near Mendota, giving it a rusty pink color, or a fawn color, as described by Featherstonhaugh, and at the same time greater tenacity and endurance under pressure—10,000 pounds per square inch. For its beauty, its regularity of bedding—which is sometimes nearly 2 feet in thickness—and its homogeneous texture, which renders it easy to shape into all forms, it is adapted to ornamental work as well as heavy masonry. It is cut, as at Mankato, into posts, sills, caps, and water-tables. For its adaptability to all uses it is worthy of being ranked with the Waverly sandstone, which is beginning to be imported into Minneapolis and Saint Paul from Ohio, and it is more enduring even than that under the action of atmospheric changes, owing to the more general and abundant dissemination of the calcareous cement, while its variegated coloring and its more lively expression make it preferable in many kinds of work. It is used in the State Lunatic Asylum building at Saint Peter. The Episcopal church and the old asylum building are also constructed from it. The Baptist church in Saint Paul is built of the Kasota stone. In old structures where it has been exposed for a number of years to the disintegrating action of the elements it shows as hard and sound as ever. It even becomes harder at first on exposure as the quarry water dries out.

The Shakopee, the upper member of the Lower Magnesian, is quarried at Kasota, Le Sueur county, for general purposes of construction, and especially for bridges, flagging, and tombstones. It is used throughout Minnesota, and in Eau Claire, Madison, and Hudson, Wisconsin; Le Mars, Sioux City, and Muscatine, Iowa; Sioux Falls, Dakota, and Winnipeg, in Manitoba. The following are some of the principal buildings in the construction of which it has been used: In the Insane Asylum at Saint Peter; trimmings in Saint Mary's church, Minneapolis; Plymouth church, Minneapolis, and Gilfillan's and Odd Fellows' blocks, in Saint Paul. The stone is a dolomite, ferruginous, and contains considerable siliceous matter. Specimens of the stone at the National Museum are dendritic. The stone at Kasota is all, or nearly all, stained with iron having a faintly-pinkish color, although originally buff. This stain comes from the flooding of the Minnesota river at early (glacial) times. The stone is subcrystalline and vesicular, with signs of irregular stratification, and is evenly and horizontally bedded in courses from 3 to 4 feet in thickness. Blocks 10 by 11 feet by 1 foot thick have been quarried, and blocks of as large size as could be conveniently handled may be quarried. Around the joints there is a recent penetration of iron and carbonaceous stain, sometimes 6 or 8 inches in the joints, having a wavy outline, according to the rate and ease of penetration by infiltrating water. This is usually cut away as waste in dressing blocks of the stone. Much of the stone at Kasota and some of the equivalent beds at Mankato have a color (designated by Featherstonhaugh as "fawn-color") not common to building stone. It is an accidental quality due to the more free penetration or chemical retention of the iron of atmospheric ferrated waters. Wherever the stone of the Shakopee formation is found so situated as to have been covered by the Minnesota river in its flood stages, or in the floods of the glacial epoch, it is uniformly so colored. In none of its layers, when found in higher land in the interior of the state, is this color found, but it has usually the buff color of the weathered siliceous limestones (non-argillaceous). The highest-priced stone of the Kasota quarries is that which is most colored by the presence of iron, being faintly reddish or pink.

Near Mankato, Blue Earth county, the Shakopee limestone is quarried for railroad-bridge construction and for general building purposes, and extensively used along the line of the Chicago, Saint Paul, Minneapolis, and Omaha railroad, the Winona and Saint Peter railroad, and the Chicago, Milwaukee, and Saint Paul railroad; in western and southern Minnesota; Eau Claire, Wisconsin; Sioux Falls, Dakota; Le Mars and Sioux City, Iowa; and the following are some of the buildings in the construction of which it has been used: The trimmings of the public-school buildings at Sioux Falls and Albert Lea, Minnesota; the jail at Blue Earth; the state normal school and other schools at Mankato. The stone is here also a dolomite, containing some siliceous matter, usually ferruginous; buff in color, subcrystalline, sometimes fine, close-grained, and sometimes open and vesicular, with cavities of half

an inch or less in diameter; signs of irregular stratification, evenly and horizontally bedded in layers often 6 feet in thickness; it is irregularly jointed, and blocks 8 by 4 feet by 18 inches have been quarried, and blocks 20 by 10 by 6 feet might be quarried. All the quarries in the vicinity of Mankato are in the same beds, and very nearly the same details of stratification are present. There is a bed of shale connected with the rock at Mankato which in some particular localities becomes more calcareous, and is possibly suitable for a cement. The light blue color which appears in the deep portions of some of the quarries indicates the original color of all the rock; on further quarrying this blue color will probably increase in amount. The Galena limestone (at first a light buff stone) at Mantorville, in Dodge county, shows the same change in the deeper layers. In the quarry of the Winona and Saint Peter railroad, near Mankato, for quarrying convenience the layers are designated as follows, from the top downward:

1st. White ledge, very fine-grained stone.
2d. Red ledge, harder and pinkish.
3d. Gray ledge, coarse-looking stone.
4th. Soft ledge, will not stand frost.
5th. Bridge stone, coarse in texture.

The Trenton limestone, which is largely used at Minneapolis, Saint Paul, Northfield, Faribault, and Chatfield, and was formerly quarried at Fountain for shipment to points farther west on the Southern Minnesota railroad, is a bluish, rather dark colored stone, that varies in value very much at different places between Minneapolis and the southern part of the state. At points toward the north, nearer the old shore-line of the Paleozoic ocean, much aluminous shale was deposited, even in those comparatively quiet times when marine animals flourished and on their death supplied a considerable calcareous sediment. Farther south the quiet, lime-producing epochs were less mixed with aluminous sediment, and were separated more distinctly by periods of agitation when large amounts of shale were deposited. Hence in this formation at Minneapolis and Saint Paul the aluminous shaly ingredient is distributed through the calcareous, and also constitutes heavy beds of itself, while at Northfield the calcareous layers are pure; at Fountain they are almost free from alumina and sand, and at the same time in passing toward the south the purely aluminous beds become less frequent as the calcareous become more numerous. The cities of Minneapolis and Saint Paul have to depend very largely on the Trenton limestone for building material or to import from other places. The stone itself has an attractive and substantial aspect when dressed under the hammer, the variegations due to the alternating shaly and limy parts giving the face a clouded appearance as of gray marble, without being susceptible of a uniform polish. Where protected from the weather the shale will endure and act as a strong filling for the frame-work of calcareous matter for a long time; but under the vicissitudes of moisture and dryness, and of freezing and thawing, it begins to crumble out in a few years. This result is visible in some of the older buildings, in both Saint Paul and Minneapolis, and has provoked a very general inquiry for some suitable substitute in those cities. The natural color of the stone on deep quarrying is blue, but it is often faded to an ashen drab to the depth of several feet, depending on the ease with which water and air find access within. The porous layers are apt to be most faded. The long-weathered surface is of a light buff color, or if iron be present in dripping water or contained in the stone as pyrites, so situated as to be oxidized, the color is sensibly deepened to a rusty yellow, and at the same time the stone is rendered more enduring on account of the irony cement. This is noticeable at Minneapolis and at Saint Paul, where the old river bluffs, formed before the last glacial epoch, have endured the exposure of a much longer period than the river bluffs between Fort Snelling and Minneapolis that have been formed by the recession of the falls since the last glaciation. The shaly portions in particular, where closely mingled with the calcareous, are so stained and hardened that the rock seems almost another formation. It becomes separated into layers 2 or 3 inches thick. Some of the first large buildings erected in Saint Paul were made largely or wholly from such iron-stained and weathered parts of this formation, and, although they do not present that uniformity of color and appearance of solidity and strength that the dark blue stone lately quarried gives to a building, the stone itself has withstood the climate and storms of this latitude more successfully than later buildings constructed wholly of the blue-stone. Toward the southern portion of the state this changed condition is not so noticeable, indeed it is not so possible. The beds are more compact and calcareous, and the effect of the elements is more superficial.

In the vicinity of Saint Paul the rock is a slightly-magnesian limestone, containing protoxide of iron. The texture is fine and semi-crystalline, usually showing signs of regular stratification, evenly and horizontally bedded in courses from 3 to 24 inches in thickness, joints 10 to 30 feet apart; blocks 6 by 2 feet by 1 foot have been quarried, and blocks 10 by 5 by 2 feet may be quarried. Saint Paul and vicinity is the only market, and the following are some of the principal buildings in the construction of which the stone has been used: The Fire and Marine Insurance building, the cathedral, the McQuillan block, the German Catholic church, the custom-house, and most of the stone buildings in Saint Paul.

In the immediate vicinity of Minneapolis the stone contains varying amounts of magnesia, ordinarily hardly sufficient to be called a magnesian limestone. The upper layers in nearly all of the quarries are made up of a siliceous dolomite.

The blue, slightly-magnesian limestone, however, preponderates at all the quarries, and silica and protoxide of iron are nearly always present in greater or less quantity. The following is a full section of the Trenton, as exposed at the Minneapolis quarries, given in descending order:

1. Dolomite, somewhat argillaceous, making a durable building stone, but generally not regarded as highly as the rock of No. 5; it contains numerous casts of fossils; thickness, 8 feet.
2. Similar to No. 1, or gradually becoming more impure with shale; thickness, 2 feet.
3. Calcareous green shale, mainly in one bed or layer; thickness, 4 feet 8 inches.
4. The last passing gradually into a calcareous shale resembling the well-known building rock of this vicinity, sometimes used for rough walls, distinctly set off from the next below; thickness, 2 feet 4 inches.
5. The regular building stone of Minneapolis. The shale which impairs this stone is intimately disseminated through the calcareous layers without showing regular lamination, yet causing a mottled or blotched exterior on being dressed; the fossil remains are usually comminuted; thickness, from 10 to 14 feet.
6. A vesicular, less argillaceous, but magnesian and rather softer rock lying near the bottom of the blue limestone and generally not distinguished from it; thickness, 18 to 24 inches.
7. Blue shale, worthless for building; thickness, 2 feet.

As to the texture of the Minneapolis stone it is generally fine and compact, seldom vesicular, and often interlaminated with shaly belts. At some places it separates into laminæ of from 1 inch to 2 inches on weathering; some of it is mottled with argillaceous spots, but is otherwise compact, though showing fragmentary fossils. The color of the stone most used at Minneapolis for construction is a light blue, and until recently it was used exclusively, but at present building stones from Ohio, Iowa, and Illinois are being introduced. Some of the building stones from other parts of the state are also being used in the city, particularly that from Frontenac and from Kasota. The Trenton at Minneapolis and Saint Paul splits under the weather along the dark argillaceous belts that pervade it, and for that reason is not now regarded as a first-class building stone. The better rubble from the upper layers of the Minneapolis quarries really embraces the best rock for dimension work, and as to quality it is as durable a rock as the highest priced; it is sold cheaper because of irregular shape in fracture, rendering it unfit for range work. However, the quarries in the central and northern part of the city do not have this rubble, nor the "soap rock", which is sold for poor rubble, that layer having been denuded by the glacial and drainage forces so as to leave only the regular "quarry rock", which is No. 5 of the section before given of the Trenton at Minneapolis. The lowest layers in all the Minneapolis quarries show some variation in the composition and texture.

The following is an analysis of the dolomitic white limestone at the Baxter quarry:

	Per cent.
Carbonate of lime	55.533
Carbonate of magnesia	26.002
Iron and alumina	3.075
Insolubles	16.220

The blue limestone which prevails throughout this section is present in the same quarry. While this formation as a building material at its northern outcrops at Saint Paul and Minneapolis is rather inferior, at its southern exposures it furnishes a dark blue stone of excellent quality. Nothing can be more suitable for heavy walls, and especially for foundations below the water-table, and for all gothic structures, than the blue limestone taken from the formation at Fountain, or at some of the quarries at Faribault.

At Cannon City, near Faribault, Rice county, the Trenton limestone is a calcareous dolomite, containing protoxide of iron and silica; color, bluish-drab; massive, uniform, fine, and fossiliferous in texture; evenly and horizontally bedded in courses varying from 4 inches to 3 feet in thickness. Blocks 12 by 4 feet by 10 inches thick have been quarried, and blocks 20 by 3 feet by 15 inches thick may be quarried if desired. It is perpendicularly jointed at intervals. The material is used for general building purposes sometimes, and formerly for table-tops and work of that character. The market is at Faribault and within a radius of 20 miles of that place, where it was used in the construction of the Deaf Mute Asylum building, Shattuck School building, Episcopal church, and the public-school buildings.

The stone from the Faribault quarries is in the same stratigraphical horizon as that in the quarries at Minneapolis and Saint Paul. A comparison shows that the siliceous and the argillaceous impurities seen at the first-named place have greatly diminished in passing from north to south. There is a shale bed underlying the building-stone layers and separating them from the underlying Saint Peter sand-rock. The beds themselves are sometimes a foot thick, but are more generally from 6 to 8 inches in thickness. On deep quarrying they combine into heavier layers.

At Minneapolis, and to some extent also at Saint Paul, there is a very different sort of stone in the Trenton limestone formation overlying the beds that are wrought, which is more enduring than the regular building stone. This does not appear in the quarries near the falls, but is seen in those near the university, where the formation has not been so much eroded. This rock is generally rejected by builders, as already stated, and is confounded with the worthless shale that separates it from the regular building-stone layers. It is an impure limestone, containing a large per cent. of silica and alumina, and also of carbonate of magnesia. It is more correctly a dolomite, resembling in that respect the rock at Red Wing and at Winona, though not having the bright, cheerful

color of the stone at those quarries. It is subcrystalline, rough to the touch, hard, but splitting to thin lenticular chips under the weather. It is of a blue color within, but on exposed surfaces becomes a dirty buff. The grain is close, except for the cavities resulting from absorbed fossils. The fragments into which the stone weathers out are brittle and somewhat sonorous under the hammer. The older portion of the State university contains a large amount of this stone, and its superior durability can there be seen. This part of the Trenton limestone is about 8 or 9 feet thick, and is separated from the blue-stone usually wrought by a thickness of 5 or 6 feet of worthless shaly rock, which builders sometimes smuggle into a wall.

Still higher in the geological scale are limestones that appear in the southern counties, known as Upper Trenton and Galena. The banks of the streams that pass into Root river in the western part of Fillmore county and in southwestern Olmsted exhibit many large exposures of the Upper Trenton, and there are many quarries in it, but they are mainly for quicklime. They might be utilized for building stone, since the rock is heavy, firm, free from shale and sand, and easily accessible. The Galena beds are extensively wrought at Mantorville and at Spring Valley, and somewhat at other points in Fillmore and Olmsted counties, and in northwestern Goodhue county. The color of this rock is buff, sometimes dark buff, although on deep quarrying the heart of the beds shows that its normal color, like most other limestones, is blue. Its composition, like that of the rock at Red Wing and at Winona, is dolomitic, comprising a large percentage of carbonate of magnesia, but it is without the quartz that is found in the limestones along the Mississippi, and is on that account less hard to quarry and cut, as well as less durable. Its texture is open, even porous, with minute cavities, and sometimes with larger openings, due to the absorption of fossils. In this latter case it presents a rough and forbidding aspect. This, however, is not common, the sedimentation having been generally so undisturbed by chemical or mechanical agencies that the layers are yet well preserved. The grain is crystalline and somewhat granular. Minute crystals of brown spar often line the cavities. It sometimes also embraces iron pyrites, which, weathering out, stains the face of the rock with iron rust. The granular texture seen in some parts of this formation, which is a character seen in most magnesian limestones, has sometimes made it pass for a sandstone. As a material for building it is a little surprising that this formation has not been more employed. It occurs in fine exposures in the southeastern part of Goodhue county, abundantly in Dodge county, as well as in Olmsted and Fillmore, along the streams, and can be extensively wrought. It furnishes a building material not only suitable for all ordinary uses in foundations and abutments for bridges, but one that cuts easily to a regular and smooth surface. Its bedding is sometimes heavy, reaching 2 or 3 feet in thickness, and the stone is strong enough to endure both pressure and long weathering. It is of a light and lively color, and in that respect has the advantage of darker-colored stone.

The Galena limestone is quarried at Mantorville for general building purposes and to some extent for monument bases. The principal markets are Rochester, Mantorville, and Spring Valley. The following are some of the buildings in the construction of which the stone has been used: Wright's hotel, two school-houses, the court-house, and Ginsburg's brewery, in Mantorville. Blocks 22 by 25 by 2½ feet may be quarried. The stone is evenly and horizontally bedded in courses varying from 6 inches to 3 feet in thickness; joints are irregular, crossing each other at varying angles. The various quarries here are near each other and furnish the same kind of rock. Mantorville is one of the old and important quarry towns in the state, but of late years, owing to poor wheat crops, there has been but little demand, and the quarries have been comparatively unproductive. The material is a siliceous dolomite containing iron in the form of sesquioxide.

The limestone of Hudson River age is quarried at Clinton Falls, Steele county, near Owatonna, for walls and buildings, but more especially for foundations at Owatonna and in the surrounding country. It is a siliceous dolomite containing protoxide of iron; in color it is a drab; its texture is sometimes slightly vesicular, but usually fine and compact; shows signs of irregular stratification, and is evenly and horizontally bedded in layers from 2 to 6 inches thick. Blocks 4 by 4 feet by 4 inches are the largest that can be quarried, on account of the frequent joints.

The Devonian limestones are of two very different sorts. One kind is found in Fillmore county, southwest of Spring Valley, and particularly along the tributaries of the Upper Iowa river. This stone in all respects except its more even and close texture, being without the porous features, is like the Galena limestone at Mantorville. Its color is the same, but its even and non-vesicular texture is enough to distinguish it from the Galena. The bedding is also less thick, being, when in exposure, usually less than 8 inches, though when quarried it is also in heavy beds. It is a yellowish, magnesian limestone, sometimes with a finely arenaceous composition, and is suitable for most purposes in common masonry. It is tolerably free from calcite lumps, but has some chert nodules. It is, however, generally useful for a cut stone in its outcrops in Fillmore county. It has been but little opened in Minnesota, principally because the region in which it occurs has not yet developed so as to create a demand for first-class stone for building. In Michigan and Ohio this formation supplies some of the most valuable limestone for building. The other sort of Devonian limestone overlies the last, and is much finer grained. It is light-colored, or sometimes nearly white, hard, and fine. It is uniform in grain and texture, and not in the least porous. Some parts of it would make a beautiful white, or nearly white, marble, if it were deeply quarried. In ordinary working it breaks with a conchoidal surface, but by some care a uniform cutting can be made in any direction. Some of the beds of this rock are about 10 inches or a foot thick, but they are more frequently about 4 or 6

inches, and can then be got out in slabs of considerable size. It is a fortunate circumstance that sometimes layers of clay are interposed between the beds, which facilitates their being obtained in sizable blocks. The most favorable point for quarrying this stone is at Le Roy, in the southeastern part of Mower county.

Limestone suitable for all purposes of building is found well exposed for quarrying along Deer creek, at Frankford, in Mower county. The age of this rock is not fully established, but is supposed to be of the Upper Silurian age. This stone is suitable for heavy masonry, being often 3 feet thick or more. The stone has about the same color as that at Le Roy, but is somewhat darker. Its texture is vesicular, with abundant calcite and some chert, and it is apparently a magnesian limestone.

SLATE.

At Thompson, where the Saint Paul and Duluth railroad crosses the Saint Louis river, the Huronian slates have been opened for the production of roofing slate, and with very good success. This enterprise is not now carried on, but there is no known reason why it should not be revived and made profitable. The slate is black, hard, and compact, fine and uniform, contains no spots developing crystals, pebbles, or other defects, and is apparently of the best quality. Considerable quantities which were taken out over ten years ago have been exposed on the ground to the weather at that place, and show no effect from such severe tests. The amount of the supply here is exhaustless, but of course some care must be exercised in selecting the beds for quarrying. Slates of different grades of hardness can be obtained, which will supply material not only for roofing, but for writing slates, tables, mantels, and all other uses to which such slate has been applied. The locality is perfectly accessible from the south by the Saint Paul and Duluth railroad, and from the west by the Northern Pacific railroad.

A good quarry in this slate was opened at Knife Falls, Carlton county, by the Saint Paul and Duluth Railroad Company, in 1880. The quarry is at a point 5 miles north of the Northern Pacific junction, near the northern boundary-line of Carlton county. Considerable stone was taken out, but none has been shipped or dressed in the condition of roofing slate. All that has been quarried was designed for flags, and the pieces are from a quarter of an inch upward in thickness and generally contain about 6 square feet, though some are larger. They are dark blue or nearly black, smooth and uniform, and well adapted for flagging, flooring, or marbleizing. The form of the natural slabs, as determined by transverse joints, is subrhomboidal and rectangular. No prices or markets were established before the whole enterprise, which must have involved an expense of $15,000 or $20,000, was abandoned by the railroad company, which abandonment is said to have been brought about in pursuance of the policy of the company to relinquish all extraneous enterprises and conduct only railroading. This termination of such a movement has had a bad effect on the reputation of the slate. Slates were quarried in 1870 on this formation at another point about 3 miles distant, and the weather has not yet injuriously affected it where used as roofing. This attempt was also very expensive to the owners, and, when the financial stringency came on, it was also abandoned. This formation appears very abundant in Minnesota farther north and east, especially about Vermillion lake, where the slates are less brittle and of a light green color.

PAVING STONE.

For pavement in ordinary roads or in the streets of cities a variety of material has been used, but in general the harder and tougher kinds of rock are the best. Sandstone is altogether too soft, unless it has been hardened into a quartzite by some method of metamorphism. Such changed sandstone is the quartzite at New Ulm and southwestward to Rock county, and also the quartzite or cemented sand-rock of the Cretaceous below New Ulm, in which the cement, being principally silica, has compacted the entire mass so as to form one very tough substance. This latter, however, is probably not obtainable in very large quantities, and its cemented condition is variable and perhaps not extensive. Still, whatever there might prove to be would, especially in connection with the Potsdam quartzites of New Ulm and of Rock and Pipe Stone counties, furnish a supply ample for that part of the state and for a large export to adjoining parts of Iowa and Dakota. The limestones of the Lower Magnesian, viz, those at Winona, Red Wing, Mankato, Kasota, and Shakopee, are better for paving material than other limestones that contain less silica, being firmer and harder and less soluble by water. Of good road material Minnesota has a superabundance. The granites, greenstones, traps, and quartzites form the most conspicuous feature in the geology of the northern and eastern portions of the state. The so-called trap-rock at Taylor's Falls is the most accessible of the firmer kinds of stone, excepting the pebbles and bowlders found in the drift scattered nearly all over the state. The granite at Saint Cloud and Sauk Rapids is also accessible, and is nearly as durable. The gneisses of the Minnesota valley are very suitable for the same use, and the rocks of the north shore, being very largely tough dolerites, are superior for this purpose. Some of the best exposures are at Duluth of stone known as "Duluth granite". These dolerites of the north shore are wrought into rounded forms on the beach by the action of the waves, and sometimes these rounded stones alone constitute the beach. They have been carried by ship-loads from Minnesota to Chicago and other cities for use in paving streets. They are found in considerable numbers in grading the streets of Minneapolis and Saint Paul, associated with similar forms of other hard rock, and are thrown with the dump and buried again. A little thoughtfulness would save thousands of dollars to each city.

FLAGGING.

So far as known, the state is not abundantly supplied with stone that is naturally and easily separable into sheets for flagging. Yet it is to be borne in mind that there has not yet been created a large demand for flag-stones, and that perhaps when the demand arises some of the quarries now in operation, or others, will be found to possess a good supply of flag-stones. Some of the beds most likely to furnish such stone of a durable character are the lighter colored, or at least the thinner bedded, portions of the red quartzite at New Ulm, or at some other points southwest of there. In the exposure of this quartzite at Redstone, near New Ulm, some of the lower layers are argillaceous and thin, and can be got in large slabs, which, with proper handling, could be broken to shape and size for flagging; but in general such beds are covered by a large thickness of firm, heavy layers of quartzite.

The Cretaceous beds at Fritz's quarry, a few miles below New Ulm, and at other places near, also will furnish a pretty good flagging, which it would be much easier to obtain than the stone at Redstone, the beds being separated by other layers of incoherent sand-rock. There are places in the Minnesota valley, above New Ulm, where the quarries would also furnish a good flagging stone, but of course, while more enduring in use, this stone would be more difficult to quarry. Of the limestones, or siliceous limestones, the beds of the Saint Lawrence or Shakopee formations are most promising. The former is in outcrop, as already stated, all along the Mississippi river from Winona to Hastings, and thence up the Saint Croix valley to and beyond Stillwater, and the latter is characteristically exposed at Shakopee, Ottawa, Kasota, and Mankato. Some of the thinner beds furnish a very superior stone for flagging, which is now somewhat used for that purpose. At the present time it is generally broken up for lime-burning or is sold as inferior building stone. The exposures of the Saint Lawrence formation at Hebron and other places in Nicollet county, and at Saint Lawrence, nearly opposite Jordan, in the Minnesota valley, are also very favorably situated for obtaining flagging; at Saint Lawrence particularly the beds are of about the right thickness. Some firm slabs of flag-stone are obtained at Kasota.

In the northern part of the state nothing is known that will answer for flagging, unless it be certain layers in the red sand-rock at Fond du Lac, or the argillite at Thompson. The former can be easily tested and readily obtained, but it would be rather soft for such use. It can be got in large slabs, but it would be refractory to work into shape and slippery in use, though very firm and durable when once laid.

IOWA.

By W. J. McGee.

The principal sources of knowledge of Iowa geology are the three reports of Owen, (*a*) Hall, (*b*) and White. (*c*) Unfortunately, the official surveys on which these reports were based were not carried to such detail as to afford more than a general outline of the geological phenomena of the state, and accordingly the published information on the subject is much less full and accurate than could be desired. Moreover, since the last of these surveys was brought to a close, additional natural exposures of strata have been discovered, the number of artificial exposures has been tripled, and, in consequence, beds probably distinct from those officially recognized have been brought to light, and material defects in the official maps have been detected.

In the dozen years that have elapsed since the publication of White's report many data have been collected by different observers. These are in part scattered through various publications, but are yet mainly unpublished. Among the latter are the observations I have made during the past four years, extending over the Cambrian, Silurian, and Devonian systems, which observations, though made in a desultory and unsystematic manner, and imperfectly connected, have been drawn upon almost exclusively in the preparation of the following descriptions, so far as the above-named systems are concerned. The descriptions of the newer systems are based mainly on the works of Hall and of White, especially of the latter, though in nearly every stage the observations of these gentlemen have been supplemented by my own. Since, however, careful and systematic geological work is yet required in every portion of the state, it is manifest that no high degree of accuracy can be claimed. Particularly reliable or particularly unreliable representations will be specifically indicated in the following pages. A few modifications in the classification of the rocks have been introduced for reasons mentioned in the detailed descriptions of stages. Synonymy, etc., may be learned from White's report, already cited.

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a Report of a Geological Survey of Wisconsin, Iowa, and Minnesota * * * . Made under instructions from the United States Treasury Department. Published by authority of Congress. Philadelphia, 1852.

b Report on the Geological Survey of the State of Iowa. * * * Published by authority of the legislature of Iowa. 1858.

c Report on the Geological Survey of the State of Iowa to the Thirteenth General Assembly. Des Moines, 1870.

GENERAL GEOLOGICAL SECTION OF IOWA.

Group. (*Era.*)	System. (*Period.*)	Series. (*Epoch.*)	Stage. (*Age.*)	*Thickness.*
				Feet.
Psychozoic	Quaternary	Glacial	Drift	200
Mesozoic	Cretaceous	Lower Cretaceous	Inoceramus	50
			Woodbury	150
			Nishnabotna	100
			Fort Dodge	35
Paleozoic	Carboniferous	Coal Measures	Upper Coal	325
			Middle Coal	150
			Lower Coal	200
		Sub-Carboniferous	Saint Louis	80
			Keokuk	90
			Burlington	125
			Kinderhook	200
	Devonian	Hamilton	Hamilton	250
	Upper Silurian	Niagara	Niagara	50 to 350
	Lower Silurian	Trenton	Maquoketa	20 to 125
			Galena	20 to 250
			Trenton	75 to 200
		Canadian	Saint Peter	80
			Lower Magnesian	350
			Potsdam	300
	Cambrian	Primordial	Sioux	100

QUATERNARY PERIOD.

DRIFT.—Under this general term are included the several beds of aqueo-chemical, vegetal, glacial, lacustral, and alluvial origin, which represent no fewer than eight distinct deposits, and which cover the sedimentary strata over more than 99 per cent. of the state. While the thickness of the drift is variable, it is generally sufficient to preclude the economical extraction of the underlying rock for industrial purposes, and at the same time to embarrass geological investigation, except in the deeper valleys of erosion; and over fully one-third of the state its depth and continuity are such as entirely to conceal the older strata.

Over much of the northern half of the state erratic bowlders of granite, syenite, and other crystalline rocks abound in the drift, and are more or less extensively employed for building and ornamental purposes. They are found in greatest abundance and perfection and of largest size in Butler, Bremer, Black Hawk, and Buchanan counties, where, as in all the northern third of the state, they either lie upon the surface or are but partially buried. Farther southward they diminish in size, become wholly buried, and finally diminish in number. The large bowlders have been most largely worked in Buchanan county, chiefly at and near Independence; but they are pretty largely employed for heavy foundations, bases, monuments, etc., at Osage, Mason City, Charles City, Waverly, Marshall, Eldora, and elsewhere. Smaller bowlders are also used for foundations, etc., either in their natural form or simply broken into irregular fragments (by blasting or by plugs and feathers), or, more rarely, dressed, in nearly every county in the northern part of the state, where they serve as a substitute for the inaccessible bedded rocks; but the demand is so variable and the supply so limited that the industry is neither important nor permanent.

CRETACEOUS PERIOD.

INOCERAMUS.—This newest stage of the sedimentary strata of Iowa consists of three conformable chalky beds, of which only the uppermost is sufficiently indurated to form a weak and friable limestone. It is not known except in the bluffs of the Sioux river in Plymouth and Woodbury counties, and it is practically worthless for purposes of construction, though the upper division is sometimes employed for cheap foundations, etc., in the vicinity of Sioux City.

WOODBURY.—The materials forming this stage are either sandstones, generally shaly and impure, or argillaceous, arenaceous, calcareous, or (rarely) bituminous shales. It is exposed along the Missouri and Sioux rivers in Woodbury county. At and in the vicinity of Sioux City the purer sandstone layers are quarried to the value of perhaps $1,000 or $2,000 per year, the product being used for common rubble, riprap, macadam, paving and curb stones, etc. The material is tolerably suitable for such purposes if care is exercised to exclude the obscurely, shaly, or otherwise defective portions. There is so much waste as to enhance its cost, but it can nevertheless be furnished at a less price than stone transported thither from better quarries.

NISHNABOTNA STAGE.—The Nishnabotna stage is mainly a coarse-grained, friable sandstone, generally quite ferruginous, sometimes gravelly and passing into pudding-stone, and rarely clayey. When cemented it is usually by iron, and it hence assumes the reddish-brown color of the hydrated sesquioxide. It is frequently obliquely stratified, and is generally massive or with very irregular and obscure bedding and jointage planes. It is exposed along the Nishnabotna river in Cass county, in Guthrie county, and in a few other localities; the only important quarry being at Lewis. A few smaller quarries are operated near Lewis, and others are said to be worked in southeastern Guthrie county.

FORT DODGE.—The stage to which it seems appropriate that this name should be applied is a deposit of nearly pure light gray, regularly-bedded gypsum, resting unconformably upon Saint Louis and Lower Coal strata, and unconformably overlain by drift, supposed to extend over an area of about 25 square miles in the vicinity of Fort Dodge. The bedding is horizontal, and it is generally distantly and vertically jointed. It is also finely laminated horizontally in alternate white and gray lines, the latter containing all the slight impurity with which it is charged. It is quite soft when first quarried, but hardens considerably on exposure. Some years ago it was quite extensively used as a building material, but it has now fallen into disrepute. Among the structures built from it are an arched culvert over Two-Mile creek, on the Illinois Central railway, and the depot building on the same railway at Fort Dodge, both of which were erected from 15 to 20 years ago. Four years ago the culvert was seen to be in good condition, and during the past season but little sign of dissolution could be detected in the depot building. Foundations built at about the same time are, however, reported to have given way. It is now almost exclusively employed in the manufacture of plaster of paris.

I have made but few and casual observations in connection with the Cretaceous rocks of the state, and hence their description is mainly taken directly from White's report. It is probable that much of the northwestern third of the state is underlain by Cretaceous strata; but the depth of the drift is so great as to prevent the actual determination of the geographical extent of the system. The classification adopted is that of White, except as regards the gypsum deposit, which is provisionally given a specific stratigraphical designation and included within the Cretaceous system. As shown by White, the deposit is apparently a precipitate of sedimentary character (*Geology of Iowa*, 1870, II, p. 300), and it hence must have been laid down in a basin isolated from the sea and subjected to gradual evaporation; and since the Cretaceous seas extended farther northeast than those of any other age between sub-Carboniferous and Quaternary times, it is regarded as most probable that this little inland basin was filled by sea-water during that period, and desiccated during the elevation that closed that period in Iowa.

The limited information as to the employment of the Woodbury sandstone for building purposes was mainly derived from incidental observations made some years ago; but from reports of a resident during the past season it appears that the material is used to about the same extent as at that time.

CARBONIFEROUS PERIOD.

UPPER COAL.—The materials forming this stage of the general Iowa section are, as far as known, pure, magnesian, argillaceous, arenaceous, and earthy limestones, generally intercalated with shaly bands and partings, together with shales, clays, sandstones, and a thin coal seam. The pure and magnesian limestones are regularly, smoothly, and approximately horizontally bedded, and generally distantly jointed by the "clay seams" of the quarrymen; though the ledges, especially in the pure limestones, are independently cut up into angular blocks of various sizes by irregularly-ramifying vertical "dry seams", which often simulate fresh fractures. The area occupied by this stage is very considerable, though most of it is so deeply covered with drift that the rocks are accessible only along waterways.

In addition to the quarries specifically reported on there are small quarries supplying local demands for common rubble (used chiefly for cheap foundations, etc.) at Glenwood, Malvern, Red Oak, Macedonia, Corning, Bedford, Clarinda, Numa, and Winterset, in southeastern Cass county, in southern Decatur county, and elsewhere, which collectively produce building material to the amount of many thousands of dollars annually; indeed the demand for building stone for all except the more costly structures in the southwestern part of the state is chiefly met by the product of such local quarries. They are, however, so irregularly worked as to render it quite impossible to collect reliable statistics of their operation and product. All of these quarries are in limestone, the sandstones being worthless for building purposes so far as known.

The dolomite, which occurs only at Winterset, and in a few ledges at Earlham, is light buff or grayish-buff, finely saccharoidal, homogeneous, tough, quite free from grit, and seldom penetrated by dry seams. It well resists exposure and the action of frost, and is in all respects an excellent stone. The pure limestone is whitish or light gray, sometimes with a bluish tinge, finely subcrystalline, the fracture being generally conchoidal. It usually occurs in only a few ledges at any point, intercalated with impure limestone, but is not confined to any part of the area of the Upper Coal rocks. It is somewhat injured by dry seams, and does not perfectly resist the action of frost. The impure or argillaceous portions are light buff, yellowish, bluish, and sometimes blue-black, especially when freshly quarried; is approximately homogeneous, fine, compact, and brittle, and much cut up by dry seams. This stone is soon destroyed by frost, especially when kept moist, as at the ground level in foundations. Both the pure and argillaceous phases are remarkably uniform in lithological character over the whole area of the stage.

MIDDLE COAL.—This division of the Coal Measure series consists of shales, clays, sandstones, and limestones, with half a dozen thin coal seams, the limestones and sandstones occurring in thin, discontinuous beds. Its strata occupy a variable, tortuous belt, bounding the area of the newer stage, but not yet satisfactorily separable, geographically, from the Lower Coal stage. St. John mentions (*Geology of Iowa*, 1870, I, p. 284) that the limestones of this stage are quarried in the western part of Dallas county, and that the sandy ledges afford a fair freestone near Adel and south of Indianola; but it appears, from inquiries made, without visiting these localities, that neither here nor elsewhere are these rocks systematically quarried to any considerable extent.

LOWER COAL.—The lowest member of the coal-bearing rocks in Iowa is mainly composed of shales, clays, and friable sandstones, with occasional thin layers of impure limestone and a number of valuable beds of coal, the whole occupying a very considerable but extremely irregular area. Over this area (which was largely determined by Hall and White) the strata are tolerably uniform in character and approximately horizontal, though sandstones predominate toward its eastern and northern margin, and in the isolated outliers, and the beds are apparently disturbed by a number of gentle parallel undulations which coincide in direction with the principal waterways. In some cases certainly, and apparently in nearly all, the lines of erosion follow the anticlinals. Moreover, its attenuated margin is deeply lobed by the erosion of the tributaries of these streams and by all minor waterways which originate within its area. Accordingly it is quite possible that the terminal portions of many of the eastwardly-extending lobes are nearly insulated; while conversely, the Story county, Pella, and other sub-Carboniferous exposures may be completely surrounded by coal-bearing strata. The rock occurs in the southeastern part of Jones county, near Oxford, but its extent is not known. A brown sandstone also occurs in the eastern part of Delaware county, 5 miles south of Dyersville, and a ferruginous conglomerate is found in small quantities in the northeastern part of Howard county; but these exposures equally resemble the Nishnabotna sandstone, and may possibly not belong to either the Cretaceous or the Carboniferous systems.

The limestones of the stage are, so far as known, worthless for building purposes; but the sandstones, which are usually coarse, more or less ferruginous, heavily bedded or massive, rather distantly jointed, and often obliquely laminated, are quarried in many localities, chiefly near the margin of the area occupied by the stage, or in its isolated outliers. At Red Rock (9 miles north of Knoxville) it yields an excellent freestone of brick-red color, which attracted much attention a few years ago, but which is now mostly abandoned in consequence of the opening of quarries in superior limestone and sandstone strata of the Saint Louis stage in the vicinity. A less valuable freestone is reported to be quarried in a small way near Ripley, and in Boone county, 10 miles west of Sheldahl. At Steamboat Rock (4 miles north of Eldora), Eldora, near Marshall, at Kellogg, and south of Sigourney, a coarse, brown, friable, ferruginous sandstone, sometimes conglomeratic, which supplies local demands for common masonry, is quarried in a primitive manner whenever the material is called for; the aggregate annual product (excluding Eldora) is, on an average, about 80,000 cubic feet, worth about $2,500, but the output appears to have been less than usual for the past year or two.

The sandstones of the outliers are, as a rule, superior to those of the Lower Coal area proper. At the Dutch colonies, in Iowa county (East Amana, Amana, Middle Amana, Höhe Amana, West Amana, and Homestead), lying from 5 to 10 miles east of Marengo, it is finer and firmer than in the localities previously mentioned, and generally obliquely laminated. It is employed in the construction of the principal buildings, including mills and factories, in the several towns. The laborers of the colonies work the quarries whenever building material is required, or they are not otherwise engaged, moving about 75,000 to 125,000 cubic feet of rubble per year; but since this labor has no financial equivalent, and the product is common property, the value of the material is indeterminate. In the outliers of Muscatine and Scott counties the rock is still more extensively utilized as a building material. In the western part of this area it is lithologically similar to that found at Amana, or somewhat coarser and more friable, as in the Hare and Starke quarries; but eastward it is finer and less ferruginous, as in a quarry near Buffalo and the Goetsch quarry, in Davenport, where it is fine, uniform, clean, imperfectly cemented, and light buff or white in color. In the last-named quarry it reposes unconformably upon Devonian limestone, both being quarried, but neither extensively.

SAINT LOUIS.—This stage is made up of three distinct divisions. The uppermost of these consists mainly of pure limestone, sometimes brecciated or concretionary, sometimes regularly bedded, compact, finely subcrystalline, homogeneous and brittle, with a conchoidal fracture, and is overlain by a bed of clay, the whole being some 40 feet in thickness. The middle member is a sandstone or freestone, usually regularly bedded, distantly jointed, firm, homogenous, and hard; its thickness never exceeding 20 feet, so far as known. The lowest bed is an equally homogeneous, compact, regularly-bedded, distantly-jointed dolomite of unusual strength, fineness, and toughness. The area over which the strata of this age form the floor of the drift is not known with sufficient accuracy to permit of separating this from the older stages of the sub-Carboniferous series; but its outcrops are known in Lee, Des Moines, Henry, Washington, Van Buren, Jefferson, Keokuk, Wapello, Mahaska, Marion, Story, Hamilton, and Webster counties; its identity in the second as well as in the last three of these counties being stated on White's authority.

The uppermost division is the least valuable as a building material, though it is largely quarried for that purpose at Franklin, Mount Pleasant, Ottumwa, Chillicothe, Givin, Sigourney, Ames, Fort Dodge, Webster City,

and elsewhere. In all of these localities it forms a fair, sometimes excellent, building stone. It has also been quarried for use in lithography, chiefly near Farmington, where the rock is similar, lithologically, to that found at Franklin. It is no longer used for this purpose, since it has been found to contain too many dry seams, often cemented by crystalline carbonate of lime. Its ordinary color is light buff, light gray, or nearly white, sometimes with a bluish tinge; and its normal texture, where of value as a building material, is fine, homogeneous, brittle, and sometimes very hard, as at Ottumwa. This phase resembles the pure limestone of the Upper Coal stage. It is, however, impure in its northwesterly extension. At Ames and at Webster City it is generally buff or yellowish in color, somewhat earthy or argillaceous, and quite similar to the impure portions of the Upper Coal limestone; while at Fort Dodge it is almost silty in part, dark blue or black when freshly quarried, though weathering to gray, and very erratic and refractory under the hammer when first extracted. It need hardly be said that the stone from these quarries does not well resist the action of frost. Little is known of the Webster City quarry further than that it supplies local demands for cheaper masonry, and that it is not largely operated. The city is in part supplied with better stone from the Farley quarries.

The middle division is largely quarried at Keokuk, Fairfield, Mount Pleasant, and Dudley. At Fairfield it is composed of siliceous sand in a calcareous matrix, and is irregularly bedded and closely jointed, rendering it difficult to find blocks of large dimensions; but it is so hard, and resists disintegration so perfectly, that a door-sill in constant use for twenty years exhibits scarcely perceptible wear. Ten miles northeast of Fairfield a small quarry, used locally, is said to yield much larger blocks of similar quality. Near Oskaloosa the rock is reported to be much the same as at Fairfield. It is here used for millstones with partial success. At Keokuk and at Mount Pleasant, but especially at Dudley, the ledges are smooth, uniform, distantly jointed, and free from dry seams, permitting the extraction of blocks 10 by 20 feet, or larger, though it is here less hard and indestructible than at Fairfield. The rock is generally gray or bluish-gray in color.

The lowest and magnesian member is extracted at Keokuk, Mount Pleasant, Chequest creek (5 miles southwest of Kilbourne), Brighton, Washington, Givin, Ottumwa, Dudley, Tracy, Pella, Durham, and Knoxville. At Washington, Brighton, and Knoxville it sometimes exhibits a styolitic structure, and is in addition rather irregularly stratified and closely jointed. At Durham, Pella, Tracy, Dudley, Givin, Chequest, and Mount Pleasant, however, it is regularly and rather heavily bedded, quite homogeneous, and distantly jointed. Its color varies from bluish-gray at Washington and Knoxville to bluish-buff at Chequest, yellowish-buff at Pella and Tracy, light buff at Givin and Durham, and whitish at Mount Pleasant; and in texture it is finely saccharoidal or compact, homogeneous, and tough, resembling in some cases the Upper Coal dolomite. At Chequest it is susceptible of a fair polish, and is widely known as "Chequest marble", and at Tracy, Pella, and elsewhere it may be carved with great facility. The bluish tinge is remarkably permanent, as at Washington, where fractures exposed for a number of years exhibited no perceptible alteration in color, and appeared almost as fresh as if just taken from the quarry.

KEOKUK.—This stage comprises two members, the upper being an irregular mass of shaly or calcareo-siliceous strata, abounding in geodes, while the lower consists of compact grayish or bluish limestone, generally regularly bedded, with shaly partings. The area covered by the rocks of this age is known to be limited, though it cannot yet be delineated cartographically. The only localities where these rocks are known to occur are portions of Lee and Des Moines counties, and a narrow belt along the Des Moines river, in Van Buren county, where they have been brought to the surface by one of the gentle anticlinals already referred to, coupled with the erosion of the valley. The stage appears, from White's observations, to attenuate and perhaps disappear toward the interior of the state.

The pure limestones of Keokuk age, like those of the Saint Louis and Upper Coal stages, are finely subcrystalline, compact, brittle, homogeneous, and hard; light gray, whitish, and slightly bluish in color; but the larger portion is earthy or argillaceous, as is much of that of the Upper Coal. These impure limestones are buff, yellowish, or bluish, uniformly bedded, separated by shaly partings, which sometimes graduate into the ledges and again develop into considerable layers of clay; they are distantly jointed, but much cut up by independent systems of dry seams ramifying through each ledge, and liable to suffer disruption and disintegration when exposed to the atmosphere and frost. The Keokuk strata are not extensively quarried, the important quarries being confined to Keokuk and Bentonsport.

The smaller quarries in the vicinity of Keokuk and near Bonaparte, 5 miles southeast of Bentonsport, are also in this stage. The material is employed to some extent for dressed caps, sills, etc., as well as for rubble, macadam, and other common grades of building stone.

BURLINGTON.—This stage, like the Saint Louis, is made up of three well-marked beds. The uppermost division consists mainly of light gray, whitish, or buff, regularly-bedded, compact, subcrystalline limestone of approximate purity, with occasional clayey or shaly partings, becoming siliceous, cherty, and irregular toward the top. The middle member is predominately siliceous, but it is generally shaly, seldom sandy, and without compact and regular strata. The lowest division is a yellowish or grayish, compact, pure limestone, regularly and rather heavily bedded centrally, but cherty both above and below. The highest member constitutes about one-half and each of the two lower divisions about one-fourth of the total thickness of the stage. Its geographical extent is probably still less than that of the Keokuk division of the sub-Carboniferous rocks, since it is known only at its typical locality, Burlington, along lines of erosion in Des Moines and Louisa counties, and in the northern part of Washington county.

The Burlington rocks are practically identical with those of Keokuk, and are similarly used for common masonry and occasionally for dressed work. They are, however, extensively quarried only at Burlington. Portions of the uppermost division are nearly white in color, fine, compact, homogeneous, and hard, with a conchoidal or splintery fracture, like the so-called lithographic limestone of the Saint Louis stage. This phase has been used to some extent for ornamental purposes, but it contains too many incipient fractures and is too liable to unexpected disruption to be of special value.

KINDERHOOK.—The rocks of this age, which occupy a singularly long and narrow belt, are of rather variable character. At Burlington nearly the whole thickness of the stage is made up of shales and clays, with a few unimportant beds of limestone at the top, which include oolitic and magnesian layers. This phase is tolerably constant throughout Des Moines county, the dolomite forming the upper, the oolite the middle, and the shale the basal and principal portion. Along English river in Washington county the dolomite is considerably thicker (the oolite remaining inconspicuous), and, though rather earthy and irregularly bedded, is quarried in a small way near Riverside and Kalona, yielding common and heavy rubble, locally used for foundations, well-rock, bridge-piers, etc.; the average annual product of the several quarries probably falling below $1,500 in the aggregate. The stage is next known in Tama and Marshall counties, on both sides of the Iowa river. Here the basal shaly division is mainly absent or concealed beneath the river level, not to appear again in Iowa, and the two calcareous divisions are of predominant importance. At Montour the oolite is heavily bedded or massive, regularly and tolerably distantly jointed, and gray or bluish-gray, weathering to buff or yellowish. On the opposite side of the river the same oolite is less heavily and more regularly bedded, and is quarried by a number of individuals for lime and common rubble, the rubble supplying the vicinity and the towns of Toledo and Tama. These quarries are generally operated by farmers during leisure time, and yield collectively perhaps 75,000 cubic feet per year, worth about $750 at the quarries, or $3,000 delivered. A similar phase is presented at Conrad, Grundy county, where the material is more extensively utilized. Near Le Grand the uppermost or magnesian bed shows a thickness of over 40 feet, while the oolite is mainly beneath the river. Here the dolomite is regularly and rather heavily bedded, distantly jointed, compact, fine, and homogeneous, and generally buff, whitish, or yellowish in color. The coarser ledges are here so extensively used for rubble, bridge work, dimension stone, and other purposes as to require a railway station for the sole use of the quarry; while the finer ledges, which are often beautifully veined by iron peroxide, are sawed into slabs and shipped to distant markets for ornamental purposes, under the name of "Iowa marble". Near Dillon the same dolomite is unusually hard and firm, and is the sole member exposed. At and near Iowa Falls the two uppermost divisions of the same stage (as identified by White) again appear; but here the limestone is pure, finely subcrystalline, compact, hard, and without a trace of oolitic structure, and the dolomite is remarkably magnesian, generally heavily but regularly bedded, though in part massive and tolerably distantly jointed. Both members are quarried quite largely. The purely calcareous bed here resembles lithographically the brittle white limestone of the Burlington, Keokuk, Saint Louis, and Upper Coal stages. Several small quarries have been opened in the Kinderhook strata toward and above Alden, along the Iowa river; but their product is insignificant. At Humboldt and Dakota both the oolitic and subcrystalline phases of the middle bed, as well as the magnesian division, are exposed and largely quarried. Near the headwaters of Lizard creek the purely calcareous division again approaches the surface over a considerable area, and is exposed in a number of localities in both the oolitic and subcrystalline aspects. It is here quarried in a small way by half a dozen individuals in both Humboldt and Pocahontas counties, the total value of the annual product falling short of $1,000. The material here appears to be of unusual strength, hardness, and homogeneity, is regularly bedded and not very closely jointed, and promises to be of great value when the quarries are properly opened and adequate means of transportation provided. In addition to the foregoing there are small quarries near Ackley and Hampton which yield thinly-bedded, "shelly", (*a*) irregular limestones representing this stage, and another of like character is said to exist near Eldora, where a ravine cuts through the Lower Coal sandstone. The product of these quarries is trifling, and the real value of the material is very small since the use of it is almost an injury to the consumer.

DEVONIAN PERIOD.

HAMILTON.—The Devonian rocks of Iowa are extremely variable, both lithographically and paleontologically, but our knowledge concerning them is meager. The predominant lithological phases may be enumerated and described in the order of their excellence:

1. The "Old State House" dolomite.
2. The Mason City dolomite.
3. The Mason City limestone.
4. The La Porte limestone.
5. The Osage dolomite.
6. The Buffalo limestone.

a The convenient term "shelly" (probably a corruption of *shaly*) is frequently applied by quarrymen in this state to rock which separates into irregular plates, generally an inch or less in thickness, and a foot or more in diameter. Such rock may not be shaly, as shown by the comparative purity of the Kinderhook limestone where it exhibits this phase. The phrase "excessively thin-bedded" might be equivalent, if the limited lateral extent of the plates were also borne in mind.

7. The Iowa City limestone.
8. The Waverly limestone.
9. The Independence limestone.
10. The Cedar Rapids limestone.
11. The Fayette breccia.
12. The Rockford shale.
13. The Independence shale.

1. The first of these is a peculiar, heavily-bedded or massive, slightly-magnesian gray limestone of remarkable homogeneity, toughness, and durability, largely made up of comminuted fragments of fossils, chiefly *Atrypa reticularis*. It is found at the North Bend or Old State House quarry, 9 miles northwest of Iowa City, not visibly associated with other strata; and only since the collection of statistics for the Census Office was completed has it been found to pass beneath apparently conformable strata of limestone of the Iowa City phase at Roberts' ferry. It is not known except in the immediate vicinity of the great bend in the Iowa river.

2. The Mason City dolomite is a rather heavily and regularly bedded brown and brownish-buff, distantly jointed, saccharoidal, homogeneous, tough, and compact magnesian limestone, lying conformably beneath pure limestone strata, and only known in the deeply-eroded valleys of Lime and Willow creeks at Mason City.

3. The third phase is a light gray or white, compact, homogeneous and brittle, finely subcrystalline, pure limestone, usually rather heavily bedded and distantly jointed, though considerably cut up by independent systems of fractures in each ledge. It closely resembles the pure limestone of the Upper Coal at Earlham, Stennett, Corning, and other localities; of the upper division of the Saint Louis at Franklin, Farmington, Mount Pleasant, Ottumwa, and elsewhere; of the Keokuk and Burlington at their typical localities; and of the middle division of the Kinderhook at Iowa Falls. Similar rock occurs elsewhere in occasional ledges, as at Garrison, Waterloo, Orchard, Floyd, Marble Rock (where the name of the town was derived from it), Osage, and Mitchell. The phase indeed appears to graduate into that of Iowa City on the one hand and into that of Waverly on the other, though it is approximately uniform throughout at Mason City.

4. The La Porte limestone is rather heavily and regularly bedded, compact, homogeneous, rather finely subcrystalline, but at the same time slightly tough. It is not quite pure, is somewhat unctuous to the touch, resists the action of frost fairly, and resembles the Mason City limestone as regards jointing. It appears to be normally bluish-gray, changing to gray or whitish on oxidation; but, as in the Saint Louis dolomite of Washington and Knoxville, the alteration is accomplished so slowly that partially-oxidized blocks remain distinctly mottled for years. A precisely similar phase has not been detected elsewhere, though certain ledges of the La Porte quarry are essentially identical with certain ledges occurring at both Iowa City and Waverly.

5. The Osage dolomite is a somewhat earthy and slightly magnesian limestone of light buff or yellowish color, and of tolerably fine, homogeneous, and compact texture. It is regularly bedded, sometimes with earthy, shaly, or cherty partings, rather distantly jointed, but sometimes independently seamed. It exhibits in a slight degree the tendency to become separated into angular fragments on exposure to the atmosphere, and especially to frost, which characterizes all of the inferior rocks of this stage. It is of rather variable character, and can only be arbitrarily separated from portions of the Waverly limestone. It occurs associated with limestones of the Mason City and Iowa City phases at Osage, Mitchell, Saint Ansgar, and Orchard; with the Waverly limestone at Waverly and Waterloo; with the Mason City limestone at Marble Rock (where it exhibits but very slight tendency to fracture on exposure), and with the Iowa City, Buffalo, Independence, and Iowa City phases at Davenport.

6. The Buffalo limestone is irregularly bedded, obliquely and rather closely jointed, blue, but weathering to gray within a year or two after quarrying, generally abundantly fossiliferous, and extremely hard, brittle, and refractory. It is quarried at and near Buffalo, where the fossiliferous portions are slightly used for ornamental purposes, chiefly for paper-weights, table-ornaments, and the like, large pieces of uniform character being difficult to procure. It is liable to become fragmentary on exposure. A somewhat similar but less hard and pure fossiliferous limestone is found at Charles City and Nashua, and unfossiliferous rock, resembling that of certain ledges of the Buffalo quarry, occur at Davenport, West Union, and in a few other localities.

7. The phase assumed at Iowa City is that of a non-magnesian but sometimes argillaceous, fine-grained, subcrystalline limestone, blue or even black on fresh exposure, but rapidly weathering to gray, buff, or whitish. It is tolerably regularly bedded, with occasional shaly or clayey partings, generally distantly jointed, but much cut up by independent systems of dry seams and fractures of fresh aspect, and it is quite disposed to become fragmentary on exposure. It occurs at Iowa City, Roberts' ferry, Muscatine, Atalissa, Garrison, La Porte (in the five last-named localities associated with other phases), Solon, Fairfax, Marion, and elsewhere. At Bristow the rock is quite similar, and at Rock Falls and West Union (in part) it partakes somewhat of the character of the Buffalo limestone. At Iowa City and Roberts' ferry it abounds in crystalline masses of the Hamilton corals, *A. cervularia davidsoni* and Farvosites (of two or three species), forming respectively the Bird's-eye and the Fish-egg varieties of the so-called Iowa City marble.

8. The Waverly limestone differs from the last in being more earthy, slightly magnesian, more yellowish in color, and still more disposed to become fragmentary on exposure. It occurs at Waverly, Shell Rock, Waterloo, Independence, Raymond, Vinton, Davenport, and Chatham, generally associated with other phases. Some blocks obtained a number of years ago from the latter locality, however, resemble the La Porte stone.

9. The Independence limestone is hard and brittle, blue, but weathering to gray, irregularly stratified or shelly, and regularly and closely, though often obliquely, jointed. It prevails near the eastern margin of the stage, as near Cresco and Lime Springs, north of Waucoma, at Fayette, Quasqueton, Independence, and in several smaller quarries. It is usually fossiliferous, fragmentary, and somewhat similar to the Buffalo limestone.

10. The Cedar Rapids limestone somewhat resembles that of Iowa City, save that it is without regular jointing or bedding, and is so extremely fragmentary as to be worthless, except for macadam, railway ballasting, etc. It occurs at Cedar Rapids, west of Mount Vernon, at Atalissa, and in part of the Davenport quarries, where it is associated with other phases.

11. At Fayette, Quasqueton, and elsewhere, a bed consisting of angular fragments of compact, brittle limestone, embedded in a matrix of similar material, occurs. It is of no value for purposes of construction.

12 and 13. Neither the Rockford nor the Independence shales yield materials that can be used for building purposes in their natural condition. Both are made up of shales and clays.

It will be observed that a number of the quarries mentioned in the foregoing paragraphs are not represented in the tables. All of these are small, except a few which have been practically abandoned within a few years. More than thirty different openings have been visited during previous years. In the aggregate the average annual product of these small Devonian quarries is about 1,000,000 cubic feet, and the value of this at the quarries is about $22,000; though the value of the stone used for building purposes is considerably less than this. The material has been used mostly for foundations and underpinnings; some for bridge work, flagging, sills, etc., and some for railway ballast and for macadam. Most of it has been used in the vicinities of the quarries; a little has been shipped from Rock Falls and from Nashua.

The Devonian rocks of the state have been casually examined by a number of geologists in different localities, and have been referred to several stages, including the Chemung, Hamilton, Marcellus, Corniferous, and Upper Helderberg; but in view of the meager knowledge of the several beds yet acquired, it has been deemed the least objectionable course to provisionally group all together under the name of the single stage to which they were assigned by White.

UPPER SILURIAN PERIOD.

NIAGARA.—This sole stage of the Upper Silurian, as found in Iowa, is nearly everywhere a buff, brownish, yellowish, or whitish dolomite; though hard, brittle, and vesicular, non-magnesian masses of gray color, burning into excellent lime, occasionally appear. Considerable portions abound in chert, which usually exists in the form of nodules; but it permeates the material sometimes to such an extent as to form continuous but generally vesicular and irregular ledges, the cavities being filled with dolomite. Other portions are friable, cavernous, vesicular, destitute of homogeneity, shelly, or cut up by dry seams. All such portions, which collectively constitute by far the greater part of the stage visible from the surface, are of course quite worthless for other constructive purposes than road-making. The portions extensively utilized for building material are either regularly and rather heavily bedded and distantly jointed, finely saccharoidal, homogeneous, and tough, and of buff, light buff, or whitish color, as at Farley, Le Claire, Littleport, Volga, Cascade, Clay Mills, Maquoketa (in part), Buena Vista (in part), Princeton, and in most of the smaller quarries of Clayton, Dubuque, Jackson, and Scott counties; finely laminated horizontally, distantly jointed, and without dry seams, finely saccharoidal and tough, and of buff, yellowish, or whitish color, as at Anamosa, Stone City, Mount Vernon, Olin, Hale, Fairview, and Buena Vista (in part); heavily bedded or massive, distantly jointed, saccharoidal, moderately tough and firm, and brown, brownish-buff, or brownish-yellow in color, as at the Williams quarry (between Postville and Clermont), Waucoma, Cresco, Brainard, and Foreston; irregularly bedded and jointed, somewhat friable, finely vesicular, imperfectly homogeneous, and varying from brown to white in color, as at Clinton, Lyons, Comanche, and Sabula (in part); tolerably regularly but variably bedded and distantly jointed, though with occasional dry seams, firm, hard, and somewhat brittle, buff or light buff, with veinings of oxide of manganese, as at Delhi, Monticello, Central City, Maquoketa (in part), Sabula (in part), De Witt, and Tipton; or, finally, tolerably regularly bedded and not distantly jointed, fine, compact, homogeneous, brittle, and blue or light blue in color, as at Manchester, where alone this aspect has been seen. In nearly all of these phases the rock discloses occasional dry seams, which are generally straight, diagonal to the jointing, vertical, and discontinuous, often terminating in both directions in a single block; which seams may be partially or wholly cemented by crystalline calcite or dolomite, generally stained with iron oxide, and never simulate fresh fractures. They are seldom abundant in the larger quarries, but are nearly everywhere a source of some annoyance to the quarrymen, since they are most likely to occur in the larger blocks. The great importance of this stage as a source of building material has already been pointed out.

The number of small quarries not represented in the tables is about 40, the average annual product of which is about 800,000 cubic feet of stone, valued at the quarries at about $18,000. The stone is used almost exclusively for foundations, principally in the vicinity of the quarries.

LOWER SILURIAN PERIOD.

MAQUOKETA.—The materials forming this stage are mainly shales and clays, with occasional irregular and discontinuous beds of impure limestone; none being of value for building purposes. Its strata only appear in a

narrow belt along the eastern margin of the Niagara stage. The stage becomes so attenuated in thickness in its northwesterly extension as to be quite unimportant both stratigraphically and geographically, though it can be traced to the north line of the state.

GALENA.—The greater part of the Galena stage consists of heavily bedded or massive and rather distantly jointed buff dolomite, of firm and tolerably compact texture, though sometimes vesicular or cavernous; but its upper portion is more argillaceous, regularly bedded, with shaly partings, and with its ledges independently but distantly fissured. The area occupied by the stage is inconsiderable, though, like the Maquoketa, its attenuated northwesterly extension can be traced quite to the state line. The rocks of the Galena stage are extensively quarried only at Dubuque, but they are extracted for local consumption near Elgin, at Elkader, near Massillon (4 miles west of West Union), and in a few other localities; the total product of these small quarries reaching about 50,000 cubic feet, worth not over $1,000. Twice this amount should also be added for the small quarries at Dubuque not specifically reported.

TRENTON.—In its more southerly exposures this stage is mainly composed of compact, hard, and brittle, blue or bluish-gray limestone, frequently rich in fossils, irregularly bedded, often shelly, rather closely jointed, and disposed to disintegrate rapidly. Northwardly it increases greatly in thickness, mainly by the addition of beds of clay and shale. It is occasionally buff or grayish in color in shallow quarries (*i. e.*, those of less depth than that to which oxidation has extended), destitute of fossils, and slightly argillaceous, when it considerably resembles the Iowa City phase of the Hamilton. The hard, brittle, fossiliferous portions, which are not greatly different from the Hamilton limestone as found at Buffalo and Charles City, are also generally slightly argillaceous, the clay appearing in irregular dirty lines or blotches after exposure.

The rocks of the stage are largely quarried at Decorah and Waukon. At Florenceville they are extracted for rubble and dimension stone to the extent of some 30,000 cubic feet, worth about $750 annually, the material supplying local demands, and being moved occasionally to Cresco and neighboring towns. The rock is here fine, compact, and brittle, breaking with a conchoidal fracture, and ringing under the hammer. It is normally blue, but is bluish-gray near the surface. At a depth it is massive, but near the surface it is divided into somewhat irregular ledges by smooth, clean, horizontal fissures. At Bluffton (between Florenceville and Decorah) it is quarried for local use to about as great an extent, though the value of the product is probably below $500. At Elgin, Frankville (6 miles northwest of Postville), Postville, and Clayton there are local quarries whose average product will equal that of Bluffton.

At Bluffton, Frankville, and Clayton the dark blue, fossiliferous phase is represented; but at Elgin and at Postville the rock more resembles that of Florenceville, though containing occasional, and sometimes abundant, trilobites. At Guttenberg both phases are tolerably largely quarried, perhaps half of the buildings in the town being constucted from Trenton limestone extracted in the immediate vicinity. The annual product of the two or three quarries here has been less than usual for a few years, but probably reaches 100,000 cubic feet, worth about $2,000. The stone is used for rubble, dimension work, and road material. A small quarry at Buena Vista (5 miles below the mouth of Turkey river) has yielded material employed in the construction of a large warehouse, and a large amount of railroad ballasting, but the average product is below $500 per year. In addition to these there are many small and unimportant quarries, some of which supply but one or two consumers, scattered over the whole area occupied by the Trenton stage.

SAINT PETER.—This stage is literally a bed of siliceous sand of remarkable purity and uniformity. It is nowhere sufficiently indurated to form a valuable building material in its natural condition.

LOWER MAGNESIAN.—Rocks of this age only appear in and along the valleys of erosion in the northeastern part of the state, where they form the summits of the picturesque bluffs of the Mississippi and the Oneota rivers and their tributaries. The material is essentially a coarse, saccharoidal, vesicular, cavernous, and non-homogeneous light buff dolomite, usually heavily but rather irregularly bedded, and without well-defined jointage planes. It is only rarely that the material is at the same time so firmly indurated, so free from irregular cavities and crystalline nodules, so homogeneous in texture, and so uniformly bedded as to be available as a building stone, and even where these several conditions are as favorable as they are ever found to be, the rock is rather coarse, irregular, and otherwise inferior. Its resistance to atmospheric action is, however, eloquently attested by the mural precipices, castellated battlements, slender pinnacles, and rugged declivities which combine to form the magnificent scenery for which its area is justly famed. It is extensively quarried only at McGregor and Lansing, though, like the Trenton, it abounds in unimportant quarries which sometimes supply but a single consumer.

In Minnesota this stage has been separated into three members (Shakopee, Jordan, and Saint Lawrence) by N. H. Winchell, while in Wisconsin a like number of probably not equivalent divisions ("Main Body", Madison, and Mendota) have been recognized by Irving; but none of these divisions can be either stratigraphically or geographically traced, nor have they indeed been clearly identified in Iowa.

POTSDAM.—This stage is predominantly sandy, and consists mainly of imperfectly-cemented sandstones, with occasionally shaly intercalations which sometimes develop into considerable beds of fossiliferous shale. It is exposed only in the walls of the deep valleys occupied by the Mississippi and Oneota rivers and their principal tributaries. It is not known to be quarried except at Lansing, where it forms an inferior material for common masonry. (The Potsdam of Hull and White is the equivalent of the Saint Croix of N. H. Winchell.)

SIOUX.—As developed in Iowa, the Potsdam sandstone is made up of hard, brittle, homogeneous, and rather fine pink or reddish quartzite, irregularly bedded or massive, and closely jointed, the jointage planes being frequently oblique to the vertical and not rectangular in the horizontal plane. It is found only in the extreme northwest corner of the state, and extends thence into Minnesota, where it is denominated Potsdam by N. H. Winchell.

There is a possibility that quarries of some importance have not been reported from some of the counties in this state. There are 19 counties known to be so deeply drift-covered as to be destitute of exposures of bedded rocks. These are Audubon, Carroll, Clay, Crawford, Decatur, Dickinson, Emmet, Fremont, Greene, Harrison, Lyon, Osceola, Monona, O'Brien, Palo Alto, Sioux, Wayne, Winnebago, and Wright. There are 32 counties in which there may be some small quarries which have not been indicated, though all possible inquiries as to their existence were made in passing through. These are Adair, Appanoose, Boone, Clarke, Dallas, Davis, Des Moines, Guthrie, Hamilton, Henry, Humboldt, Jasper, Jefferson, Keokuk, Lee, Louisa, Lucas, Madison, Mahaska, Marion, Mills, Page, Plymouth, Polk, Ringgold, Shelby, Union, Van Buren, Warren, Washington, Woodbury, and Worth.

The remaining 48 counties were so thoroughly examined that it is quite certain that no important omisssions have been made.

MISSOURI.

BY G. C. BROADHEAD.

GENERAL GEOLOGICAL SECTION.

1	Quaternary	Alluvium.			
		Loess.			
		Drift.			
2	Tertiary?				
3	Cretaceous.				
4	Carboniferous	Coal Measures	Upper Coal Measures.		
			Middle Coal Measures.		
			Lower Coal Measures.		
		Sub-Carboniferous.	Chester group		
			Saint Louis group.		
			Keokuk group.		
			Burlington group.		
			Chouteau group	Chouteau limestone.	
				Vermicular sandstone and shales.	
				Lithographic limestone.	
5	Devonian.				
6	Upper Silurian.				
7	Lower Silurian				*Feet.*
		Hudson river			60
		Receptaculite, or Galena group			40 to 180
		Trenton			100 to 200
		Black River and Bird's-eye			50
		Calciferous	Magnesian limestone series	First Magnesian limestone	150
				First or saccharoidal sandstone	130
				Second Magnesian limestone	200
				Second sandstone	150
		Potsdam		Third Magnesian limestone	300
				Third sandstone	80
				Fourth Magnesian limestone	300
			Potsdam sandstone		5 to 90
8	Archæan	Porphyry	Huronian.		
		Granite.			

ARCHÆAN.

This includes the granites and porphyries and their associated and intrusive beds in southeast Missouri. The granites are generally coarse in texture, feldspathic and quartzose, deficient in mica, red in color, or else of various shades of gray, sometimes blending into a reddish-gray. They crop out in massive beds in the northern portions of Iron and Madison counties and in the southern part of Saint François county, with isolated exposures in Sainte Genevieve and Crawford counties. They afford our best quality of building stones. In some localities there is evidence of disintegration and decomposition on a grand scale; as, for example, 8 miles west of Fredericktown. At this place a well sunk 75 feet in depth passed entirely through granitic sand. In the western part of Madison county, at Lloyd's, south of Blue mountain, we also find evidence of considerable disintegration. These are probably due to chemical causes.

The phenomenon of rocking-stones is exhibited near the Ozark quarries, 4 miles southwest from Iron Mountain.

In the northern part of Madison county, east of the Saint François river, gray porphyritic granite appears over an undulating district near the Iron Mountain railroad. West of the Saint François river, the red granite rises into mountain peaks.

A syenitic granite forms a "shut-in" (*a*) on Saint François river near the Einstein mine, forming the "rapids" in Saint François river. It is traversed at this place by a dike of black dolerite 44 inches wide bearing S. 60° W. A few miles north of this, also on the river bank, we find it containing numerous specks and scales of micaceous iron and also much pyrites. Half a mile west the granite is traversed by a narrow dike of black dolerite 11 inches wide at the north end and 4 inches at the south end. From the north end it bears S. 32° W. for 30 feet, thence it gradually curves to S. 82° W. a distance of 5 feet. The adjacent granite wall has been slightly darkened and indurated by contact.

At the "Lloyd" place, in Sec. 15, T. 33, R. 5 E., a shaft in decomposed syenite has revealed a vertical dike 18 inches wide bearing northeast and southwest. Two hundred feet northwest another shaft reveals a north and south dike of similar rock 2 feet wide. The dike is of a gray dioritic character. A quarter of a mile east there is a greenstone dike 8 feet wide bearing a little west of north. Washings of sandy débris thrown out show a good deal of deep black magnetic-iron sand. Washings in the roads at several places within a few miles also reveal a good deal of this sand. In the southern part of Saint François county, west of Saint François river, a pit has been sunk on a rich deposit of micaceous iron which, being very soft, was at first supposed to be graphite.

The granite is also sometimes traversed by quartz veins, as in Sec. 2, T. 33, R. 5 E., and Sec. 6, T. 33, R. 6 E.; also on Cedar creek, where very large quartz crystals have been obtained. At the Einstein "silver" mines, in Madison county, the rocks indicate an association of diorite and serpentine. The exact position and relation of the beds could not be ascertained, as all work had been suspended, but the specimens left include serpentine, green and violet-colored fluor, clear and white quartz, argentiferous galena, wolfram, iron pyrites, and zinc-blende. The massive rocks near the river are red and gray granite, with red porphyry just west of them.

Only recently has much attention been directed to the quarrying of granite. There are but two quarries worked to any extent, the stone from which is used for paving streets and for general building purposes, principally in the city of Saint Louis. The stone from a quarry 4 miles west of Iron Mountain, Iron county, has been used in a pavement on Washington avenue, Saint Louis, for about 6 years, and the pavement is still in good order. The flagging around the Southern hotel, at Saint Louis, is also of this granite; also the front of the residence of Mr. Charles G. Stiefel. The amount of granite which may be obtained in this locality is practically inexhaustible. The eastern portion is a stratum of gray granite probably a mile in width. It has not been found farther north, but extends southwardly into Madison county for a distance of about 5 miles. The red or reddish-gray granite lies west of this, and is probably several miles in width, extending southwardly into Madison county, where it is wider in its east and west extension and more red in color. It extends south more than 10 miles, nearly to the mouth of the Little Saint Francis river.

The granite from the quarry at Knob Lick, Saint François county, is a coarse, feldspathic rock, made up of red feldspar and limpid quartz, with rarely a dark-colored bronze or black mica. It occasionally contains *lenticulæ* or ellipsoidal pockets of fine-grained, micaceous, gray granite, and these spots are often pyritiferous. Otherwise the quality of the rock on the whole seems good.

On the surface there are in several places large, rounded bowlders, some 20 feet high, resting on a small foundation, and some rocking-stones also occur. These large masses are roughly outlined and sent to market for building purposes. The smaller blocks are rough-dressed into 6-inch paving blocks and shipped to Saint Louis. Vertical joints sometimes occur, and a discoloration of 3 inches sometimes appears. One inch of the weathered crust occasionally crumbles off.

Feldspar has for several years been taken from the Sainte Geneviève quarries and used in glazing certain ironware.

Porphyries are often exposed in Madison, Iron, Wayne, Saint François, and Reynolds counties, and form the highest peaks in this region, being elevated from 200 to 660 feet above the valley. The foot of these mountains is

a A local term signifying that steep, rocky cliffs approach close to each bank of the stream.

generally flanked by porphyritic conglomerate, or limestone and sandstone of Potsdam age. The testimony of the rocks goes to show that previous to the formation of sandstone and limestone the country presented the appearance of rough porphyry knobs rising from 1,000 to 1,500 feet above the sea. In these depressions was the Potsdam sea, in its early ages quite tempestuous, as is evidenced by the conglomerates and coarse sandstone, chiefly formed of eroded fragments from the Archæan rocks. These sandstones occupied the shore-line of the Potsdam sea. In the course of time these waters became more quiet, and calcareous sediments with occasional sandy matter were formed; but observation shows that this deposit in no place extends along the Archæan slopes over 350 feet above the present valleys.

The porphyries, in their typical and most common form, seem to be a fine-grained, impalpable mixture of orthoclase and quartz, generally of a red, brownish, or purple color, sometimes dark gray or black, and porphyritic chiefly from the presence of feldspar crystals and often grains of crystallized quartz. Most of the porphyries on their edges show a shade of red; many of them are banded and show cleavage planes; in some we find well-marked lines of stratification, and some even show ripple marks, indicating a sedimentary origin. At Pilot Knob the porphyry incloses rounded pebbles, and epidote, hornblende, and serpentine occur; also beds and veins of specular iron represented on a large scale at Pilot Knob, Iron Mountain, and Sheppard mountain, some of the ore at the latter place being magnetic. Slate, resembling roofing slate in character, occurs on Buck mountain, in Iron county, and dikes of diorite and dolerite are sometimes seen.

At the so-called Tin mountain, in Madison county, the porphyry is traversed by coarse dioritic dikes and black dolerite, and on the waters of Captain's creek a dike of coarse syenitic greenstone, 75 feet in width, cuts the porphyry. In Sec. 16, T. 32, R. 6 E., there is an interesting exhibit of a series of dikes traversing dark porphyry (see Fig. 8 in *Missouri Geological Report*, 1874). Against the porphyry wall on the east are 10½ feet of greenstone, next west a few inches of dolerite, then 4 feet of porphyry, then 2 feet of greenstone, then porphyry. The course of the dike is S. 45° W.

In Iron county, in Sec. 9, T. 32, R. 4 E., a dike of hornblende rock, standing several feet above the general surface like a wall, can be traced north and south for one-eighth of a mile. On Gray's mountain, in Wayne county, and in the southeast part of Iron county we find exposed beds of steatite. In the northeast part of Reynolds county and the northern part of Madison county eruptive porphyry has been found of a gray color, and containing large crystals of white feldspar.

In Iron county are found amygdaloidal rocks flanked with porphyry. The amygdules are of a white mineral. A few miles southward the porphyry contains blue crystals.

A good exhibition of a dolerite dike in porphyry is on Mine La Motte property, at Jack diggings, and there is another dike at a cave on Rock creek. The porphyry is generally very hard and difficult to quarry.

SEDIMENTARY ROCKS.

A section of the unaltered Sedimentary in connection with the Archæan of southeast Missouri is about as follows:

1. Twenty feet of coarse, sometimes vitreous, sandstone, the second sandstone of Missouri geologists.
2. One hundred and twenty-five feet chert beds, with some clay and quartzite; contains *Murchisonia straparollus*, orthoceras, and a few species of trilobites, typical of the calciferous sand-rock.
3. One hundred to 300 feet of magnesian limestone, chert, and quartz, crystalized in drusy cavities; corresponds to the Third Magnesian limestone.
4. Magnesian limestone, 100 to 150 feet.
5. Fifty feet gritstone and lingula beds, to be referred to the Potsdam age.
6. Ozark marble, 5 to 50 feet.
7. Five to 90 feet sandstone and conglomerate.
8. Porphyry, } Archæan.
9. Granite, }

The Lower Magnesian limestone, with the lingula beds just below, incloses the lead mines at Saint Joseph, in Saint François county, and also the mines at Mine La Motte. The galena is found with these rocks in horizontal beds between the layers of limestone, or occurs as a replacement of limestone beds, or is disseminated in the limestone; and these I regard as by far the richest lead deposits of the west.

The Third Magnesian limestone may be found over the greater part of 20 counties of Missouri, often forming mural escarpments along the streams, and sometimes extending to the highest hills. It is generally lead-bearing. It is both coarse and finely crystalline, and is often a pure dolomite of a bluish-gray or flesh color. It very rarely contains shale beds; but, especially in the upper part, there are some thick chert beds. At the lead mines of Washington county it is often cavernous, and includes numerous drusy cavities lined with minutely-crystallized quartz. At some of the mines, especially those of central Missouri, it has undergone a decomposition, and quantities of dolomitic sand are thrown out. It is well exposed along the Osage river from 10 miles above its mouth to the

line of Benton county; on the Gasconade from 20 miles above its mouth to its head, and on the two Pineys. It is seen on Osage river, first near Castle rock; passing up stream it gradually rises, and at the south line of Osage county it attains a thickness of 180 feet. It is often cavernous in the middle and lower beds, and sometimes forms natural bridges across streams. Many of the caves occur in this limestone, and saltpeter has been made from the clay deposits on the floor of the caves. Of note we might name Friede's cave, 10 miles northwest of Rolla. Other caves are found in Maries, Pulaski, Miller, Ozark, and in other counties of south Missouri. This formation also seems to be the source of many large springs in south Missouri, from which flow those bold, swift, clear streams, affording unsurpassed water-power. On the Osage, in Miller, Morgan, and Camden counties, the Third Magnesian limestone forms steep, mural escarpments and wild, picturesque scenery.

The second sandstone lies next above; it is generally coarse, whitish, or slightly brown, tinged by iron, occurring more often in thick beds, and affords a good building stone. It is often the top rock on the cherty hills of south Missouri; and the pineries, when found, generally grow here. It is also the formation containing most of the iron deposits of central Missouri.

The Second Magnesian limestone chiefly forms the Missouri bluffs from Saint Charles county to the west line of Cole county, often extending from the foot of the bluffs to their top. It contains very few beds suitable for building purposes, but the lower 25 feet are thickly bedded, some dolomitic, and with some intercalated beds of sandstone, affording a very good coarse building stone; for example, near Rolla, at Hermann, the Osage and Moreau, near Pacific railroad, at Jefferson City, and near Stoutland, in Camden county. But above these beds there is scarcely 1 foot in 50 feet of this formation suitable for building purposes. This is also occasionally lead-bearing. Most of the limestones in the upper half are readily acted on by frost. The middle and upper portions contain numerous green and drab shale beds, with many intercalations of concretionary chert, sometimes assuming curious grotesque forms.

The saccharoidal or first sandstone is found along the Mississippi hills from near Sainte Genevieve via Plattin creek, through Jefferson county, the western part of Saint Louis county, thence up the Missouri river, chiefly capping bluffs nearly as far west as Jefferson City. It is also pushed up to view on Sandy creek, in Lincoln county, near Auburn, and on the north line of Lincoln, west of Prairieville, and on Spencer creek, Ralls county, near the Saint Louis, Hannibal, and Keokuk railroad. It is generally a pure white sandstone, containing 99 per cent. of silica. It is well exposed at Crystal City glass-works, where it is used in the manufacture of fine plate-glass. At this place it is pure white and soft, and about 40 feet are exposed. At Pacific, Franklin county, it is well exposed for 100 feet, the upper 70 feet being a pure white soft sand; the lower part is tinged with oxide of iron. Due north of this, on the Missouri bluffs, Saint Charles county, it is 133 feet thick. Thirty miles east of this, or a few miles west of Saint Louis, borings reached it at 1,300 feet below the surface.

This sandstone is regarded as superior for glass-making, but it is often not sufficiently coherent for building purposes, though there are a few exceptions, namely, the stone used on the Missouri Pacific railway at Berger and between Hermann and Gasconade. Some quarries on the hills near by afford a beautiful pink-banded sandstone. Obscure fragments of a large species of orthoceras have been met with in Gasconade county, some of which measure 8 inches in diameter, others nearly 2 feet.

The First Magnesian limestone is found in Pike, Ralls, Lincoln, Saint Charles, Warren, Callaway, Boone, Franklin, Saint Louis, Pettis, Jefferson, Sainte Genevieve, and probably in a few other counties. Its greatest thickness is about 150 feet. It is generally easy to work, and forms a durable building stone of some beauty. Its prevailing colors are drab and buff. It caps the hills at Pacific, Franklin county. Missouri college, Warren county, is built of it, and very good quarries can be opened near by.

The Black River and Bird's-eye formation is probably found in Lincoln, Pike, Ralls, Saint Charles, Saint Louis, Warren, Franklin, Jefferson, Perry, Sainte Genevieve, and Cape Girardeau counties, but is wanting in central and southwestern Missouri. The upper beds are often full of winding vermiform cavities. The lower often have minute specks of calcite, and are likewise varied in color and would sometimes polish into a handsome marble. Such are found in Warren county on the hills near affluents to the Missouri, and are well exposed near heads of Tuque creek and Charette. The colors are drab, pink, purple, flesh-color, and buff. Another handsome variety found in Warren county has a brown appearance, with dark, almost black, winding lines, as of fucoids. Some of these would undoubtedly look handsome if polished, and are also durable. *Ormoceras tenuifolium* and other characteristic fossils have been found.

The Trenton beds, lying above the Black River beds, occur generally in thin layers of a bluish-drab color and may generally be found resting upon the Black River beds. At Danville, Missouri, and on Loutre river, near west line of Montgomery county, also at some places in the northern part of Lincoln county, it occurs whitish or else variegated, with many specks of calc spar disseminated, and appears very well when polished. The upper beds are almost entirely made up of numerous fossils, including *Orthis*, *Pleurotomaria Murchisonia*, with occasionally *Ceraurus pleurex anthemus*.

The Upper Trenton or Receptaculite limestone is found from Cape Girardeau, along the river counties, to Jefferson county, thence northwest to the town of Pacific and along the Missouri bluffs from Saint Charles county

to the eastern part of Warren county, thinning out westwardly. It is also found in Lincoln, Pike, and Ralls counties, resting on Trenton. It is quite cavernous in these counties, but in the counties on the Missouri and lower Mississippi it is a good building stone, and it also burns into an excellent quality of lime. The upper beds are brownish-gray, the lower a white, crystalline limestone. In Warren county the upper 20 feet is a light gray, the lower 8 feet a dark brown limestone. *Receptaculites Oweni* is everywhere found. We also find *Chætetes lycoperdon* and sometimes a trilobite. It corresponds in age with the Galena group of northern Illinois, but is not galeniferous in Missouri.

The Hudson River formation is found only in some of the counties on the Mississippi river. The beds are chiefly shaly, and are sometimes very pyritiferous. I regard this group as the source of most of the mineral springs of northeast Missouri. It affords some good flag-stone beds in Lincoln and Pike counties.

The Upper Silurian is best developed in Perry and Sainte Genevieve counties, where occur several hundred feet of drab and variegated limestone, which looks handsome when polished. In Pike county we find a drab and brownish limestone, sometimes in very thick beds, closely resembling the Grafton beds, and as useful for building purposes. We find this at Bowling Green, Paynesville, and between Frankfort and Louisiana. In Warren and Montgomery counties and the eastern part of Callaway county there are about 20 feet of a coarse, gray, crinoidal limestone, which is said to be a good "fire rock".

The Devonian is not of sufficient importance to take rank among building stones. It is best developed in Callaway county, where it affords many fine organic remains.

SUB-CARBONIFEROUS.—In the lowest, the Chouteau or Kinderhook group, we find at its base, at Louisiana, 55 feet of dove-colored, compact limestone, having a conchoidal fracture. This rock has every appearance of a lithographic limestone, and was so named by Professor Swallow. In other portions of the state the same limestone is represented by a thickly-bedded dolomite, and as such it is found on Sac river, in Cedar county, and at Taborville, in Saint Clair county.

Above this limestone are the vermicular sandstone and shales, characterized by winding, vermiform cavities from northeast to southwest Missouri. It is a friable, easily-worked sandstone, sometimes affording good beds for building purposes. The thickness, including the shale beds, is about 75 feet. Above this is the true Chouteau limestone, the upper beds of a coarse, gray, and sometimes ferruginous, crinoidal limestone, containing *Leptæna depressa* and *Spirifer marionensis;* below this is a thickly-bedded magnesian and sometimes argillaceous limestone, containing geodes of quartz and calcite and occasional chert beds. Where not too subject to frost action it affords a useful building material; as such it is found in Pike, Lincoln, Ralls, Boone, Callaway, Pettis, Cooper, and Greene counties. The lower part is formed chiefly of thin layers of dove colored limestone, which was seen 100 feet thick a few miles west of Sedalia.

The next above is the Burlington group, called by Professor Swallow the Encrinital. In Saint Charles county we find at the top about 17 feet of chert, with alternations of red clay. The middle beds are gray and coarse; the lower gray and brown, generally coarse and encrinital. Crinoid stems are commonly diffused throughout, the lower strata sometimes abounding in well-preserved *Crinoideæ*. This group is found at Burlington, Iowa, Quincy, Illinois, Louisiana, Missouri, and is well exposed on the Mississippi bluffs in counties north of Saint Louis, and from the western part of Saint Charles county, in remote hills, as far as Howard. It is occasionally met with in southwest Missouri, in Cedar, Dade, Greene, and Christian counties, where it is often cavernous, containing large and beautiful caves. The streams in Greene and Christian counties owe their origin chiefly to springs in this formation.

The upper beds of the Keokuk group are sometimes shaly, with geodes of quartz, and some of them are quite beautiful. The lower beds are gray and bluish-gray, with lenticular and concretionary chert beds. *Archimedes, Hemipronites crenistria*, and crinoid stems are numerous, and some fish teeth are found. This is the limestone of Keokuk, Iowa. It is found in the central part of Saint Charles county, in Saint Louis, Boone, Howard, Monroe, and Cooper counties, and is especially well developed in southwest Missouri, from Henry county southwest. It is the lead-bearing rock of Dade, Jasper, Cedar, Newton, and Lawrence, and is also found in McDonald and Barry counties. It is, in part, equivalent to the siliceous group of Tennessee, and is well developed in Benton county, Arkansas. It is probably 300 feet thick in its greatest thickness, and affords good quarries for building purposes. The Saint Louis group is best developed in Saint Louis and Saint Charles, and is also found in Lincoln, Lewis, Clark, and Knox counties. It is generally a compact, dove-colored, or finely-crystalline ash-gray limestone, with generally a splintery fracture. It is much finer grained than any other group of the sub-Carboniferous. It is also cavernous in Saint Louis, Saint Charles, and Lincoln counties, as shown by occasional funnel-shaped sink-holes which communicate with subterranean passages. The outlets of these sink-holes about Saint Louis have generally become filled, and ponds are the result. The characteristic fossils are *Melonites, Lithostrotion, Productus*, and *Hemipronites crenistria*, with numerous *Bryozoa*, with sometimes beautiful *Crinoideæ*. The lower or Warsaw division abounds in *Archimedes* and *Pentremites*.

The Chester group of 200 to 300 feet of limestone, with a sandstone, is found in Perry and Sainte Genevieve. The sandstone, often ferruginous, is found in northeast and southwest Missouri. Good quarries of this sandstone may be opened near Newtonia, Newton county; near Lamonte, Pettis county; in eastern and northern portions of Cedar and near Lamine, in Cooper county, and a very good quarry is worked near Sainte Genevieve.

The Coal Measures include the Upper Coal Measures (barren), 1,300 feet; Middle Coal Measures (productive), 320 feet; Lower Coal Measures (productive), 300 feet.

In Atchison there are exposed 180 feet of rock, including, at top, 40 feet of sandstone and red shale beds, with limestone and beds of calcareous shales below, containing well-preserved remains of mollusca, some of them presenting a strong Permian type. Below these are chiefly shale beds, with some limestone and occasionally sandstone, but with very little coal or even bituminous shale. There are thicker limestone beds in the Upper Measures than below, and they are also better for building purposes than those of the Middle and Lower Measures. Nevertheless some (especially the blue limestones) contain a good deal of pyrites, and are necessarily inferior. Those most suitable may be quarried at Kansas City, Jackson county, and in Cass, Clay, Platte, Andrew, Holt, Nodaway, Atchison, Daviess, Livingston, Mercer, and Harrison counties.

The middle series are chiefly sandstone, with some limestone beds and some coal beds of workable thickness, but rarely contain good beds of building stone. The Lower Coal Measures are the productive measures; they also contain beds of valuable sandstone for building, with numerous outcrops in southwest Missouri. Much of it is also suitable for making grindstones. The quarries near Miami station, in Carroll county, and near Meadville, Linn county, are the best in north Missouri, the others being inferior. In southwest Missouri most of the sandstones are bituminous.

Recapitulating, we would briefly say that the granite of southeast Missouri is the best material for building purposes. The pure limestones are generally of good quality. But few of those of the Upper Carboniferous are durable, nor are many of the beds of the Second Magnesian limestone. The sandstones are most eagerly sought after, chiefly because they are easy to quarry and to work into shape. They also answer better for city work. The best include the Potsdam of southeast Missouri, found in Madison, Saint François, and Iron counties. Others may include the sub-Carboniferous of Sainte Genevieve, Newton, Cedar, Pettis, Howard, and Cooper counties; also, the sandstones of the Carboniferous, found among the Lower Coal Measures of southwest Missouri, chiefly in Barton, Vernon, Cedar, Saint Clair, Henry, Johnson, and Carroll counties. The second sandstone along the Osage and on hills of southwest Missouri is also a good building stone.

SAINT LOUIS QUARRIES.—The most extensive limestone quarries in this state are located in and near the city of Saint Louis. The formation is the Saint Louis division of the sub-Carboniferous period. The extent of the quarry industry in this locality is not so much due to the superiority of the stone as to its accessibility to the Saint Louis market. A representative section of the quarries is shown at Mr. Moran's quarry, which shows 20 feet of loose material; 20 feet of thin, shelly limestone, in layers from 3 to 8 inches in thickness; 3 feet of brownish-colored limestone, containing some chert. From this quarry a specimen of *Productus marginicinctus*, a very rare fossil peculiar to this group, has been obtained.

The stone from this quarry is used for the construction of foundations and other ordinary building purposes, and for street pavements, especially for macadam. The stone from the best Saint Louis quarries is strong and durable, and is also well adapted to the manufacture of lime. Its principal use has been in the construction of foundations. The excavation has been carried at one quarry to a depth of 60 feet, but at present the quarry is not worked to a greater depth than 40 feet, 20 feet of the lower portion of the excavation being filled with water. A section at this quarry shows 8 feet of cap-rock; 8 feet of limestone in thin layers; 9 feet of limestone in layers 12, 4, and 2 inches thick, and below this a massive, heavy bed of limestone; still lower the beds are from 1 foot to 2 feet thick, this being the most applicable for building purposes. The quarry of Mr. Philip Steifel has become somewhat noted for its fine mineral specimens, including calcite, pearl-spar, dog-tooth spar, millerite, and fluor-spar. The fluor-spar is of a yellow color; the calcite is white, or colored on the outside with millerite. In some places the limestone has a greenish tint from the presence of nickel-sulphide. The millerite has bunches of stray hair-like crystals of a bronze color, and each crystal is a delicate hair-like mineral. It has been found penetrating the calcite and extending from side to side in the limestone. It is also frequently found associated with the pearl-spar.

Among the most valuable of these quarries as regards the quality of the material are three at Cote Brilliant, about 2½ miles from the city of Saint Louis. Its development is only retarded by its being at a greater distance from the market than many of the other quarries.

A section at one of these quarries shows 25 feet of loose material; 15 feet of gray limestone, in layers about 3 inches in thickness; 4 feet of limestone, in layers of variable thickness; 2 feet of close-grained gray limestone; five 3-inch layers of gray limestone; one 22-inch layer of gray limestone; and 15 feet of limestone below the water level.

The best layers are pure limestone, susceptible of being quite highly polished, very strong and durable, and quite well adapted for architectural purposes.

The formation in the quarry of Mr. Gottlieb Eyerman probably belongs to the upper portion of the Saint Louis group, though it may belong to the next higher, the Chester group.

JEFFERSON CITY QUARRY.—The greater part of the quarry product is used at present by the Missouri Pacific Railroad Company for the construction of bridges; the small fragments are used for ballast, and small slabs are sold to citizens of Jefferson City for ordinary building purposes.

The following is a section at this quarry:

1. Soil and clay	6 feet.
2. Unevenly-bedded limestone and chert, in thin beds, suitable for ballast only	12 feet.
3. Fine-grained homogeneous rock, in even thin layers, locally called "cotton rock"	4 feet.
4. Gray limestone with numerous small cells filled with white powder	2 feet.
5. Chert beds	2 feet 6 inches.
6. Drab, evenly-bedded limestone, also called cotton rock	9 feet.
7. Gray, hard, cellular limestone, generally preferred for bridge construction	10 feet.

No. 6 is similar to the rock which was used in the construction of the state-house, which was erected about forty years ago. It is occasionally slightly discolored with stains of iron, of which minute globules and specks are seen, apparently changed from pyrites. The layers from this rock are of quite uniform thickness, many of the 4- and 6-inch layers making a very handsome paving stone. It has been quite extensively used in Jefferson City, where it has been termed cotton rock, by which name it is also known in other localities in this state. The prevailing color of this rock is drab, but in some localities it has a bluish tint, and is liable to disintegrate rapidly on exposure to the action of frost. Some of the drab layers also readily disintegrate on exposure to the weather. The best of the material needs to be quarried early enough in the season to allow the quarry water to become dried out before the stone is exposed to the action of frost.

No. 7 is a harder rock, and is not well adapted for cut work, though a very desirable material for heavy bridge construction, for which little dressing is necessary, and for which the qualities most desirable are those of strength and durability. The rocks at Jefferson City may all be referred to the Calciferous sand-rock group, known in Missouri as the Second Magnesian limestone series. Fossils are very rarely found. A section of 200 feet may be seen at Jefferson, and only a *lingula* is found in the upper beds; the other beds abound in fucoids. Lime manufactured from some of the layers possesses hydraulic properties.

BOONVILLE QUARRY is located on the bluff side of the Missouri river, just above the railroad bridge, and about 12 feet above the ordinary water-level in the river. When the river rises to the level of the quarry operations are necessarily suspended. The bluff rises steeply above the quarry for over 100 feet, so that the quarry cannot advance far inward on account of the rapidly-increasing amount of cap-rock. The layers of stone are generally tolerably even, and from 10 to 16 inches in thickness, with occasional partings of calcareous shale. A vertical section of quarry rock 16 feet in thickness is exposed. The strata dip slightly to the west. A little to the east, at the bridge, about 30 feet of gray, cherty limestone are exposed, containing, as far as could be seen, only specimens of an *Archinedipora* and a turbinated coral. The quarry rock lying above this also contains specimens of *Archimedes*.

SEDALIA QUARRY.—The product of this quarry is used locally for foundations. The strata quarried lie at the junction of the Chouteau or Kinderhook group with the Burlington beds. The following is a section of the quarry:

Loose material	5 feet.
Gray ferruginous limestone, in two layers	5 feet.
Buff limestone, shading to blue below	3 feet.
Shales	1 to 3 feet.
Blue limestone, with chert concretions and some masses of calcite	5 feet.

The floor of the quarry rests on a rock similar to the lowest which has been quarried. The lowest beds are the least durable, the upper 5 feet of limestone being quite durable. These two layers belong to the Burlington group, and the beds below them to the Chouteau.

A number of small quarries have been worked in this vicinity. From some of these blocks 4 feet thick may be obtained, all, however, containing more or less chert concretions and masses of calcite. One of the older quarries shows much of the rock shattered by frost.

CLINTON QUARRY is located about 4 miles south of Clinton, Henry county. It furnishes material to the town of Clinton, principally for sidewalk pavements. The stone is an argillaceous limestone, and occurs in a stratum about 15 feet in thickness, and in layers from 2 to 10 inches in thickness. The thinner layers are drab-colored throughout; the heavier layers have a lead-blue color in the interior, and those layers which have not been exposed to atmospheric action also have the lead-blue color. Below this quarry rock occurs a seam of bituminous coal 4 feet in thickness, which is one of the best coals of southwest Missouri. Below this again there are 9 feet of blue shales, with ironstone concretions to the level of the water in Grand river. Similar beds occur near Brownsville, Sabine county, and may be referred to the same geological age.

KANSAS CITY QUARRIES.—The stratum of limestone designated in the *Missouri Geological Reports* as "No. 87, general section, Upper Coal Measures", has been quarried extensively at quarries in bluffs of Kansas City and for 2 miles further east; also in a quarry opposite the Union depot, Kansas City, now abandoned on account of expense of stripping. The rock is also occasionally quarried in bluffs at and above Rosedale. Its color is generally a light gray, becoming locally a bluish-gray, and, when exposed, a lighter and often ferruginous gray. The middle portion of about 9 feet is beautifully oolitic, and is most valuable for building; it works freely and is easily dressed.

Below Kansas City the stripping at first is only a few feet, but of course increases as the operations extend into the bluffs.

Limestone No. 90, Upper Coal Measures, lying a little above, is often quarried and used for ordinary foundation work, while the limestone under consideration is used for general building purposes. It may be seen in the basement walls of the Merchants' exchange, the *Journal* office, and the building at Twelfth and Washington streets, Kansas City. It contains the characteristic coral *Campophyllum torquium* (O. and S.). It is generally evenly bedded in layers from 6 to 16 inches in thickness, and is much used in foundations. It is apparently durable and of more than usual strength. Its texture is homogeneous, and often has numerously-disseminated bright calc-spar specks. The color in the quarry is a grayish-drab, weathering to a brownish-drab, and shows a brownish discoloration along the joints.

Limestone No. 96, of Upper Coal Measures, also found here, is a bright gray rock with numerous specks and short lines of calcite. It contains also many fossils whose shells are of pure calcite, or else the interior is nicely crystallized. The strata are generally from 6 to 9 inches thick and of very irregular bedding. The entire stratum is 30 feet thick. An examination of the various quarries in Kansas City indicates that about 50,000 cubic yards of rock have been removed and used in the city during the past twelve or fourteen years. This includes from 9,000 to 10,000 cubic yards from the bluff opposite the Union depot, 30,000 cubic yards from southwes Kansas, and the remainder from south Kansas. The various railroads have probably taken out and used 10,000 cubic yards not included in the above.

There is quite a number of localities in Missouri where limestone has been quarried or may be quarried, beside those in which there are actually working quarries as represented in the tables. Three miles north of Canton, Saint Louis county, the Central Marble and Stone Company has recently opened a quarry in the sub-Carboniferous formation. The beds vary in thickness from a few inches to 8 feet. Considerable quantities of this stone have been quarried for bridge abutments, foundations, and for flagging. The stone has a uniform texture and gray color, but becomes darker on exposure to the atmosphere; and this may prove a defect if the discoloration does not go on uniformly. The quarries are located less than half a mile from the Saint Louis and Keokuk railroad and one mile from the Mississippi river.

Near Bowling Green, Pike county, the Niagara limestone has been quarried in a small way for the past forty years, and has been quite largely used for bridge abutments on the Chicago and Alton railroad, and occasionally for the construction of buildings. A dwelling in Bowling Green, built about forty years ago, is of this material, and the stone still looks well and shows no signs of disintegration. There are two quarries. A section at one quarry shows 4 feet of soil and gravel, 4 feet of shelly limestone, and 12 feet of building stone in three layers, the upper of which is 2 feet in thickness, and the two lower each 5 feet thick. This stratum of building stone is separated from a stratum of equal thickness below by 1 foot of shales. This last stratum of building stone consists also of three layers, 4, 6, and 2 feet in thickness. At the other quarry about 40 feet of rock are exposed in layers from 1 foot to to 2 feet in thickness. The stone when first quarried has a bluish-gray color and weathers to a brownish-buff color.

Near Glencoe, Saint Louis county, the Trenton limestone has in former years been quarried for building purposes. There are at present quite extensive quarries still in operation, but their product is all manufactured into lime. At Cape Girardeau, Cape Girardeau county, is quarried the Lower Silurian limestone, most of the material being burned, and that which is most suitable being reserved for purposes of construction. At present some of this stone is being shipped for repairing the state capitol of Louisiana, which was built of this stone, and was partly destroyed during the late war. The quarry is situated about three-quarters of a mile from the wharf, on the Mississippi river, and the stone was at one time quite largely shipped to the south. An analysis of this rock by Dr. A. Litton, for the *Missouri Geological Report*, gave carbonate of lime, 99.57; silica, a trace; alumina, a trace.

The total thickness of rock exposed at the quarry is about 30 feet, the upper portion being in thinner layers and a little darker in color than the lower. The lower portion is a beautiful white limestone, and blocks 6 feet in thickness could be obtained.

Near Rolla, Phelps county, quarrying has been done in a small way in the lower portion of the Second Magnesian limestone. This stone has been used for the construction of culverts and bridge abutments, and near the same place a thinly-bedded, hard, and durable limestone occurs which has been used for sidewalks.

Some of the limestones in southeast Missouri have been called marbles. The Cape Girardeau limestone has been termed a marble by some. In the *Kansas City Review of Science and Industry* the marbles of southeast Missouri are described; and it is given as the reason why these marbles have not been extensively developed, that they usually occur in beds not of sufficient thickness to furnish blocks of adequate size for the purposes for which marbles are usually employed. It states that near the head of Cedar creek there are several outcrops of variegated red and drab marbles. A section of rocks on a southeastern branch of Cedar creek shows 10 feet of coarse magnesian limestone resting on 10 feet of light drab marble of fine grain traversed with brown veins. Near the mouth of Cedar creek, Madison county, some of the finest exposures of the most handsome varieties of marble occur. It is handsome when polished, and the outcrops show that it is very durable. At the head of Tom Suck creek, in Reynolds county, are thick beds of flesh-colored marble. Two miles north of Cape Girardeau, on the land of Dr. Thomas Holcombe, are outcrops of variegated purplish-red limestones, with occasional calcite specks in heavy layers. Marbles of fine texture passing through various shades of flesh-color, yellow and green, pink, purple, and chocolate, all handsomely blended, are said to occur in Sainte Genevieve county. These marbles occur

in the Potsdam and Niagara formations. The Potsdam marbles are found on Stout's creek and Marble creek, in Iron county; Cedar creek, Marble creek, and Leatherwood creek, in Madison county; and Tom Suck creek in Reynolds county. The Niagara marbles are found in Cape Girardeau and Saint Genevieve counties.

Near Mooresville, Livingston county, limestone in the lower portion of the Upper Coal Measures has been quarried since 1866, but the quarries have not been regularly worked. A section there shows 1 foot of soil, 4 feet of shelly limetone, 2 feet of clay shale, 1 foot of bituminous shales, 6 inches of clay shales, from 2 to 3 feet of blue fire-clay, and 9 feet of oolitic limestone valuable for building purposes. The rock is rather hard, quite strong and durable, and is especially applicable for heavy masonry. This same formation has also been quarried in hills 5 miles south of Princeton, Mercer county, near the line of the Chicago, Rock Island, and Pacific railway; also on the Wabash, Saint Louis, and Pacific railway, Clay county, about 8 miles from Kansas City. It may also be found near the base of the bluffs at Kansas City, and at several places near Pleasant Hill, Cass county, where it is locally termed cotton rock, and is said to withstand a higher degree of heat than many other limestones.

At Forest City, Holt county, there are several limestone beds exposed, and also a soft sandstone, but the stripping is generally so heavy that the best layers of the rock cannot be extracted with profit. Limestone also crops out 2 miles above Forest City, and beyond this for 20 miles no building stone occurs.

Near Amazonia, Andrew county, 14½ feet of evenly-bedded, ferruginous gray, and somewhat oolitic limestone occurs. A quarry of this rock was formerly worked 2½ miles northeast of Savannah, and the stone was transported by wagons to Saint Joseph and used in the construction of buildings. Similar quarries might be opened near the line between Andrew and Buchanan counties, and the same formation also crops out near Atchison, Kansas.

Near Greenwood, Jackson county, the Missouri Pacific Railroad Company has opened a quarry, but the material is used principally for ballast, and only a small amount has been used for the construction of culverts. Oolitic limestone of the Upper Coal Measures has also been found near Greenwood, and is used for purposes of construction on the Missouri Pacific railroad. The stone is well adapted for rough masonry.

Near Pleasant Hill, Cass county, there are several quarries situated in different localities which have occasionally been worked. The stone has been used principally for the construction of railroad bridges and culverts, and for local purposes. The formation belongs to the Upper Coal Measures, and consists of a number of limestone beds, some of which are oolitic and some shelly. Blocks 2 feet in thickness and of any length and breadth desired may be obtained.

At Neosho, Newton county, a whitish-gray oolitic limestone is quarried for lime. This stone works freely, and would be well adapted for purposes of construction. A coarse, dark gray limestone is also quarried near Neosho, some of which contains many chert concretions.

The sub-Carboniferous limestone has been quarried for local use at Springfield, Greene county. The quarry rock shows a face of 10 feet in depth of coarse, gray limestone. The upper beds resemble the Keokuk limestone, and the lower beds are more of the Burlington type. The geological divisions recognized in Iowa, Illinois, and eastern Missouri cannot strictly be sustained in southwest Missouri.

The Second Magnesian limestone has been quarried near Marshfield, Webster county. The exposure shows one bed 33 inches in thickness of buff limestone. This appears to be a durable stone, easy to quarry and to dress. It is covered with but little cap-rock, but the stripping would be slightly increased as the excavations would be extended into the hill. There are two good exposures a few hundred feet apart.

QUARRIES OF SANDSTONE.—At a quarry located 1½ miles west of Miami station, Carroll county, there are two grades of material produced. The poorest quality contains many plant remains, and shows dark lines of fragments of plants, along which it is often fractured by frost. The best quality is free from these defects, and is a rather beautiful gray sandstone. There is a vertical face of about 70 feet exposed, the lower 45 feet being without any seam of bedding, but containing occasional concretionary masses of harder sandstone. At the top there is a depth of about 6 feet of soil and clay, and below this are 20 feet of rough and sometimes shelly sandstone layers. The quarry rock is a rather coarse, gritty, sandstone, making an excellent building stone, and being also valuable for the manufacture of grindstones. The concretionary masses are of no value whatever. They have some argillaceous layers interstratified, and also contain many nice fragments of plant remains. Although there seem to be no bedding planes in the lower 45 feet, still there are a few faint, banded, dark carbonaceous streaks occurring from 6 to 12 feet apart. The absolute percentage of waste material embraced in the concretionary masses amounts to about one-fiftieth of the entire mass. The concretionary portions disintegrate quite rapidly on exposure to the weather, but the other material is very durable. This quarry has been actively worked for about fifteen years, and the rock has been shipped to various markets in Missouri, Kansas, Iowa, and Nebraska. Eastwardly along the bluffs the rock has a more brown color, and is not so highly esteemed.

The Warrensburg quarries are of the same geological age as the above. At the quarry of Messrs. Bruce & Veitch the rock when quarried often shows planes of cross lamination, and this, although otherwise of good quality, is not of sufficient value for shipping purposes, but is used locally for ordinary purposes of construction. Considerable loss results from this defect. The planes of these laminæ are separated by carbonaceous matter. The stone in this quarry is quite soft when first taken out, and hardens on exposure. Various openings have been made in this vicinity which are not now worked. From one of these 6,000 cubic yards were excavated, and

from another 500 cubic yards. Three-quarters of a mile northwest, on the land of Mr. Bunn, a coarser sandstone of the same geological age appears, about 20 feet in thickness, forming a solid bluff on the Blackwater for several hundred yards, and seems to underlie an area of about 10 acres.

Quarries 2 miles north of Warrensburg occupy a tract of probably over 200 acres in sandstone of the Lower Coal Measures. The total thickness of this sandstone is over 100 feet. The quarries have not developed the entire thickness suitable for building purposes, only 45 feet in depth having been quarried.

The sandstone hills are bounded on the north by Blackwater river, on the west by Post Oak creek, and on the east by Potts branch. Approaching Warrensburg from the north we still find sandstone, but of an inferior quality. In the railroad cuts and southward, and throughout the town, and for a short distance north, the rock is generally brown and soft, and crumbles to powder on exposure. It also sometimes alternates with shaly beds, and sometimes incloses beds of ferruginous conglomerate, and but rarely is it suitable for building purposes.

Northwardly, as we approach the quarries, the rock is more homogeneous, the color becomes a light gray, and bluish-gray in deeper quarries. Concretionary masses of a harder sandstone not easy to work, in fact worthless for shipping, sometimes occur. These contain many carbonaceous stains and fragments of calamites and other plants. A trunk measuring over 1 foot in diameter, with its bark half an inch in thickness changed to bituminous coal, was taken out. It is supposed to belong to a coniferous tree, probably *Dadoxylon acadicum* of Dawson.

North of the Blackwater good quarries have also been opened, and over thirty years ago columns for the court-house at Lexington, Missouri, were cut out. Those columns are still entire, and are discolored only by time.

The Normal School building at Warrensburg was the first structure of note in which this stone was used, but since then it has been largely shipped to many places, including Saint Joseph, Kansas City, and Saint Louis, Missouri; also Chicago, Illinois, and Lincoln, Nebraska.

In 1871 the quarries were opened, and in 1874 one firm shipped 900 car-loads over the Missouri Pacific railway. A block 20 by 6 by 2½ feet was taken out and used in the Chamber of Commerce building at Saint Louis. The rock weighs 140 pounds to a cubic foot when dry, but only from 145 to 150 pounds when first quarried. It forms a large proportion of the face-stone of some Saint Louis dwellings, and it was also used in the Union Depot building at Chicago. It stands the test of time very well. It is not known to have scaled off, but after long exposure it becomes darker on the surface and somewhat stained.

The Miami and Warrensburg quarries are systematically worked by means of channeling and wedging. No powder is used except for removing the cap-rock.

A quarry in Clinton, Henry county, furnishes stone for ordinary construction for local use. A section of the quarry shows 3 feet of loose material, 4 feet of sandstone in layers from 1 inch to 4 inches in thickness, and below this 7 to 8 feet of sandstone in layers from 2 to 3 feet in thickness.

The Sainte Genevieve quarry is located about 1½ miles from the Mississippi river, which furnishes the means of transportation. Blocks of the largest size desired can be obtained at this quarry. Pieces 150 feet long, 20 feet wide, and 10 feet thick are often channeled off and loosened with the wedges.

The Insurance building at Sixth and Locust streets, Saint Louis, was chiefly built of this stone, including the figures on the top. The stone has been much tarnished by the smoke of the city. Among the other structures of this material are the Singer Sewing Machine building in Saint Louis, the approaches to the Saint Louis bridge, the arsenal at Rock Island, Illinois, and the state capitol of Iowa. Everywhere the stone has proven very durable. The quarry shows 25 feet in thickness of good uniform rock; the layers, 1½ to 5 feet thick, can be split readily into thin slabs if required. It is occasionally false-bedded, and then contains fragments of plant remains, chiefly carbonized. The thin layers are very much ripple-marked and the texture of the rock is generally homogeneous. It is soft when first quarried and hardens on exposure. It is a good fine grit, and a number of grindstones have been made of it.

The geological age of the formation is the Chester group of the sub-Carboniferous. The bluffs near by show about 25 feet of gray limestone of the Saint Louis group lying below it.

KANSAS.

GEOLOGICAL SECTION.

			Feet.
1	Tertiary	Pliocene sandstone	150
2	Cretaceous	Niobrara	200
		Fort Benton	200
		Dakota	500
3	Permian	Limestone and shales	1,000
4	Carboniferous	Upper Coal Measures: Limestone, shale, and sandstone	1,300
		Middle Coal Measures: Shales, coal, sandstone, and limestone	370
		Lower Coal Measures: Sandstone, limestone, shale, and coal	950
		Sub-Carboniferous limestone	150

GENERAL DESCRIPTION.

SUB-CARBONIFEROUS.—The sub-Carboniferous occupies a very limited area in the southeast corner of the state, but is highly galeniferous, as the lead mines in southeast Kansas occur in this formation.

CARBONIFEROUS.—The Carboniferous, as developed in the Lower Coal Measures of southeast Kansas, incloses some thick and valuable coal beds. It also includes many beds of sandstone of an excellent quality for building purposes and good flag-stones. These may be found of good quality and well exposed in Cherokee, Crawford, Bourbon, Neosho, Labette, Montgomery, Wilson, Woodson, Greene, and Elk counties.

The Middle Coal Measures include several good beds of workable coal, and coal has been mined at Oswego, Fort Scott, Thayer, and near Toronto, and in Osage county. In Bourbon and Linn counties we find several thick limestone beds, but the western outcrops in Greenwood county are chiefly of sandstone.

The Upper Coal Measures in northeast Kansas include a number of limestone beds, with a good deal of shale and some sandstone, but in southern Kansas we find but few beds of limestone, nor do the Upper Coal Measures include many strata desirable for building purposes.

The Permian is made up of beds of drab-blue shales, with occasional limestone strata. In the lower series we find many excellent beds of rock for building purposes; some of the strata are slightly magnesian. The middle beds are now very much worked; in fact quarries are now opened and successfully worked upon all the lines of railroad where this rock is found. The character of the rock does not materially differ in the various quarries, whether in northern, central, or southern Kansas. The building stone of the lower strata is not so soft as that higher in the series. The color is always the same shade of drab or buff. The beds are all softer than those of Carboniferous age; and, being at the same time durable, they are much sought after by builders. While I call these rocks Permian, I must say that the contained fossils have also been obtained from the Upper Carboniferous of Missouri and Kansas; in fact, I believe nearly every well-known Permian fossil of Kansas has also been obtained from the known Upper Carboniferous strata of Kansas City, Missouri. Lithologically the rocks seem different, and we have mostly to be guided by their general appearance, which is very easily recognized even in small specimens.

CRETACEOUS.—The Dakota group is easily recognized, it being composed entirely of sandstone or shales. The sandstones are sometimes of a dirty white color, but are more often a ferruginous brown. Good specimens of fossil leaves of dicotyledonous plants are sometimes found; also occasional layers of clay, ironstone, and some thin deposits of a poor quality of coal.

The Fort Benton group in the lower part consists of dark shales, with beds of brown limestone in the upper part, which are very much used for building purposes. Although this rock is very soft, it is otherwise very durable and strong enough for buildings of several stories in height. One bed, banded red or brown and buff-brown, I have traced from Mitchell county through Russell and Ellsworth counties to Rush county. It is easily wrought with a common saw, and forms handsome walls, but is too soft for sidewalks.

The Niobrara group of western Kansas affords the white-chalk beds, which furnish a very handsome white stone, but it is too soft for many purposes. It is extensively developed in western Kansas. This formation contains many rare and interesting remains of extinct vertebrata. The Tertiary is confined to northwest Kansas.

The building stones of Kansas, although extensively used, are much softer than those of the states east, but, being easily worked, are being used now in many cities. Most of the Permian strata are too cellular or porous.

QUARRIES.—The stone quarried near Irving is used at Atchison, Kansas City, and on the line of the Union Pacific railroad, which passes at a distance of about half a mile from the quarry. The rock is quarried for a distance of three-quarters of a mile in the bluffs south of the railroad. The upper or western quarry is from 15 to 20 feet above the valley; the lower quarry is from 30 to 40 feet above it. The outer rock is blasted off and used for ballast on the railroad. After the stripping is taken off a level floor is sometimes exposed from 20 to 30 feet wide, and extending several hundred feet along the hill. The limestone formation quarried here is of no great thickness. At the upper quarry there are 3 feet of shales and soil, and below this three layers of limestone, the first 8 inches in thickness and the other two each 13 inches in thickness. At the lower quarry there is 1 foot of soil, and below this are four layers of limestone 9, 12, 16, and 19 inches in thickness, respectively, the last sometimes divided into two layers. The stone is quite soft and easily quarried, and is also easily dressed when first taken out, but hardens on exposure. The strata are very nearly horizontal and the beds are of quite uniform thickness. For the construction of railroad bridges and other like structures the stone requires but little dressing.

From a quarry on the hill-top 1 mile southwest of Frankfort the stone is used principally for foundations, though a church and a school-house and some storehouses have been constructed of it. There are other small openings both to the east and to the west of it. The hill is about 150 feet high, and the quarry rock occurs near the summit, with shales below, while a good bed of building stone appears near the base of the hill. The beds here worked are apparently the same as those quarried near Irving, and dip to the west from 80 to 100 feet in 7 miles.

The Atchison quarry furnishes stone for ordinary building purposes for local consumption. The limestone is here only from 4 to 8 feet in thickness. Sometimes it is cross-laminated, when it can only be used for common purposes. The bedding is generally even and horizontal.

Stone near Manhattan is quarried chiefly on the hill-top, about 200 feet above the valley of the Kansas river. A large portion of that used for the superstructure of buildings is taken out about 30 feet below the summit of the hill. A section of the rocks here is about as follows: Soil, 1 foot; limestone for bridge construction, 16 inches; limestone, 11 inches; flag-stone, 4 inches; two layers of limestone, 12 and 14 inches; depth not exposed, 30 feet; shaly, bluish limestone, 2 feet; building stone, 1 foot; and dark shale to the base of the hill, 170 feet, with a few limestone beds and red shale about half-way down.

The stone used for bridge masonry is cellular and coarser than the other, but is equally strong and durable. Of the stone from these quarries there have been constructed in Manhattan an addition to the college building, six churches, the Adams hotel, and several fine residences.

There are about 35 common buildings in Topeka built from the stone from a neighboring quarry. They are all roughly built and laid in mortar. Some buildings have brick fronts, with stone in the remainder of the superstructure. This stone is also used in foundations. From another quarry the stone is shipped to various points along the Missouri Pacific railroad in Kansas and Missouri. This stone was used in the construction of the Congregational church and the public-school building at Emporia, Kansas, and an opera house is now being constructed of it in the same town. The Missouri Pacific Railroad Company has selected this material for the construction of shops, one about to be built at Parsons, Kansas, and another at Sedalia, Missouri.

The stone from a quarry near Lane, Franklin county, is used principally at Ottawa and at Garnett, and some has been shipped to Chicago. One of the buildings of the asylum for the insane at Osawatomie was built of this stone. There are two varieties of stone obtained at this quarry, one a little darker in color than the other, and more uniform and compact in texture. The darker-colored variety has been dressed and sent into the markets for several years under the name of "coralline" limestone. It is sometimes called oolitic limestone, being largely composed of small fossil fragments very much like the Indiana oolitic limestone and having also a similar appearance. This variety has a very firm, compact structure, and is susceptible of being quite highly polished. In the lighter-colored variety the fossil fragments are many of them larger and not so uniform in size, showing some evidence of stratification in alternate layers of coarser and finer material; and the interspaces between the fossil fragments are not well filled, giving the stone a rather open and vesicular structure. This stone being easily quarried and dressed, is quite extensively used for buildings and trimmings. The quarry which is here most largely worked is on the point of a bluff about 100 feet in height. A branch of the Missouri Pacific railroad passes along the base of the hill, and provision might easily be made by which the stone could be placed on a car at the quarry, but at the present time it is drawn a distance of 1 mile to the station. A section of the quarry shows the following: Loose material, 4 feet; vesicular buff limestone, one layer 4 feet in thickness and another 1 foot in thickness; gray, irregularly-stratified limestone with some chert connections in layers from 2 to 6 inches in thickness, 6 feet; blue shale in thin laminæ, 1 foot; irregular layers of buff limestone, 2 feet; gray limestone, 4 feet; and bluish-gray or drab oolitic limestone, 6 feet. This last has lately been most extensively used for building purposes. The layers are from 18 to 24 inches in thickness. These beds are all referred to the upper portion of the Carboniferous period. They are also well exposed along the bluffs of Pottawatomie creek from near Lane to Garnett. The upper quarry rock has been quarried at Greeley on the hill-top and used in railroad masonry. It has also been quarried near the Lawrence and Southern railroad, north of Garnett, and appears in the Marais des Cygnes bluffs near Ottawa for a distance of 15 miles to the east. Good specimens of fossils can sometimes be obtained from this formation.

The geological age of the formation in which the Cottonwood quarries are located is probably the middle or upper part of the lower beds of the Permian period. The rocks here lie below those quarried at Marion Center and Florence, and are probably above the Dunlap stone. Blocks of any length and breadth desired, and 2½ feet thick, can be obtained from these beds. The quarries are easily worked by channeling and wedging. The stratum of quarry rock is, however, only about 6 feet in thickness, overlaid by a few feet of thin limestone layers and shales. The stone is used for general building purposes at Kansas City, Saint Joseph, Omaha, Des Moines, Pueblo, Denver, Lincoln, Atchison, Leavenworth, and Topeka. The material may be seen in the west wing of the state-house and in the basement of the post-office at Topek; in the basement of the depot at Pueblo; in the court-house at Leavenworth; in Creighton college at Omaha; in the depot at Atchison; in the Missouri Valley Life Insurance building at Leavenworth; and in numerous other buildings along the line of the Atchison, Topeka, and Santa Fé railway.

The beds quarried at Marion Center belong to the Middle Permian, and are at a horizon above those quarried at Cottonwood station, as has already been stated. A general section here shows: Flag-stone layers from 2 to 6 inches in thickness, 5 feet; magnesian limestone, 16 inches; yellowish-drab soft limestone, uniform in texture, easily dressed, and used for the construction of buildings, 23 inches; and drab-colored limestone, considerably fractured and containing numerous chert concretions, 20 feet. The material from this quarry has been used in the construction of the asylum for the blind at Wyandotte, and the asylum for the insane at Topeka.

The Florence quarry is now worked only to a small extent for flagging, and occasionally some building stone is taken out. Most of the stone quarried is manufactured into lime and cement, the lower beds being used for lime. The excavations extend along the side of a hill for a distance of about 1,000 feet. A section here shows: Local drift, 4 feet; drab limestone in thin layers used chiefly for lime, including also flag-stone layers and some stone which has been used for purposes of construction, 14 feet; below this are 6 feet of rough layers of limestone; 2 feet

of yellow shales; and 6 feet of rough limestone, sometimes apparently in two layers, with occasional cavities sometimes 2 inches in diameter. These strata are evidently equivalent to those at Cottonwood station, all of well-known Permian type, with typical Upper Carboniferous fossils. This stone was used in the construction of a sugar factory at Sterling, Rice county, and of a church at Topeka.

The formation quarried at Augusta probably belongs to the Upper Permian beds. The quarry rock lies at the base of a hill and includes 6 feet of soft, buff-colored limestone in layers 1 foot and 2 feet in thickness. A few feet higher in the hill flag-stone layers occur 2, 6, and 8 inches in thickness. This stone is a little harder than the building-stone rock, and is used principally for sidewalks. Another building-stone quarry has been opened 1½ miles south of Augusta, where the rock presents a favorable appearance. Although quite soft, the stone is sufficiently strong for all ordinary structures and is quite durable. It has been used in the construction of some stone buildings at Augusta and at Wichita. Its largest use is perhaps for foundations and trimmings.

There are probably a half dozen irregularly-worked quarries of the same kind of stone around and in Fort Scott. It is locally used for buildings, walls, foundations, and also for pavements. There are several houses built of it, and it stands the wear of from ten to fifteen years exposure very well. It turns to a brownish color on long exposure, and it possesses all the strength required for common structures. The layers are generally separated by thin, brown, calcareous, shaly bands, often containing fragments of *Crinoideæ* and other known Carboniferous fossils.

The following is a general section of Fort Scott strata: Limestone, 4 feet; calcareous shales, 1 foot; bituminous shale, 4 feet; coal, 8 inches; shales and fire-clay, 3 feet; hydraulic limestone, manufactured for that purpose here, 5 feet; blue and bituminous shales, 3 feet; coal, 18 inches; fire-clay, 4 feet; and shales and sandstone, about 75 feet.

The stone quarried at Winfield has a uniform light drab or gray color, and is soft and very easily worked. It is quarried by means of plugs and feathers, the holes being bored with a common 1½-inch auger having no point. These holes can be bored by one man at the rate of 6 inches in depth per minute. The stone has a handsome appearance and a good reputation for durability. It is shipped for general architectural purposes to Wellington, Ottawa, Leavenworth, Topeka, Atchison, and Wichita, Kansas; and to Kansas City, Missouri. A hotel, two school-houses, several churches, and other buildings have been constructed of it in Winfield, where over 10 miles of sidewalk have also been paved with flags from the quarry of Messrs. Hodges, Moore & Co. Some of the flags laid down are 10 feet long and 8 feet wide, and much larger sizes can be obtained. The rock occurs in layers from 4 inches to 2 feet in thickness, and the fine even stratification allows the heavier beds to be split into thin flags. There are usually from 4 to 6 feet of good building stone capped by from 3 to 5 feet of rough limestone.

COLORADO, CALIFORNIA, MONTANA, UTAH, ETC.

By William Foster.

In collecting data for the following report, notes were obtained from ledges in regions where the quarry industry is but slight; in some cases observations were made on ledges not yet quarried for building purposes.

The whole line of the foot-hills in the eastern slope of the Rocky mountains, in Colorado, is of outcrops of sandstones which vary considerably in color and texture. They are quarried in many places both for local use and to ship to Denver, which is the chief market for them all.

At Fort Collins a very compact sandstone is taken out for "footings" and foundations of all kinds. It is especially applicable to this purpose on account of its being capable of withstanding great pressure. It is also split into flags for sidewalk paving, but its color makes it objectionable for superstructures, being striped with different shades of reddish-brown. There is another sandstone near the same locality which can be quarried in blocks of any size required and in any quantity; it has a uniform light color and fine grain, and cuts almost as easily as chalk, but grows much harder on exposure.

At Morrison, in Jefferson county, are quite extensive quarries of both red and almost white sandstone of the Jurassic period. The white is only fit for foundations, but the red is a favorite stone for trimmings and also for whole buildings. It absorbs a large amount of water if left lying on wet ground, and then falls to pieces if exposed to frost, but it lasts well in masonry.

At Manitou, El Paso county, an almost white sandstone of the Cretaceous period is quarried, which is now being used in Denver in the construction of Tabor's new opera house; also in the new Union depot, and in many other buildings for trimmings.

At Cañon City, where the Arkansas river cuts through the Cretaceous beds, are two quarries just opened: the Branford on one side and the Berlin on the other. The stone is light greenish in color and cuts very easily, and is being taken out at the Branford quarry for the walls of the new court-house for Arapahoe county at Denver.

At Coal Creek, near Cañon City, is another good sound stone. Still farther south, at Trinidad, Las Animas county, stone is quarried and shipped to Denver. Some "Trinidad stone" was put into the James office building in Denver. A little red granite split from bowlders has been used from a locality owned by the government, the

Platte cañon, between Jefferson and Douglas counties. It will not polish, on account of an excess of mica and hornblende. There are plenty of fine granites all through the mountains, but on account of the expense of working and transportation to market they are not used.

In the immediate vicinity of the town of Castle Rock there is a large amount of lava (rhyolite) quarried, and, as with other stones, Denver is the chief market. The Denver and Rio Grande Railroad Company has used a good deal of it for stations, etc., along the line of its road.

The rock splits in all directions easily with a hammer, has great strength in proportion to its weight, and makes a very handsome building with a stone face or rubble work. It will not take a polish or even answer for nice cut work, as it is porous and full of soft places called "mud-holes" by the workmen.

The only building stone which is quarried in Wyoming is at Sherman, the highest point on the Union Pacific railroad. At this point, the summit of the Black Hills, the road cuts through a very heavy body of red granite similar to the Scotch, but with much larger crystals. The monument to Mr. Ames is being quarried and cut at Sherman. Mark Hopkins, of San Francisco, had some taken out for his residence in that city, for steps, vases, etc.; his tomb at Sacramento is also built of it. The stone is very hard to work, and the sharpest tools are required, or the crystals of feldspar will fly out instead of cutting.

There is plenty of good granite in both Montana and Idaho, but there is no demand for an article which would cost so much there. A little stone has been used in the roughest kind of buildings, such as storehouses, breweries, and for foundations of some buildings, all taken from bowlders. Utah has a great variety of fine stones fit for buildings—marbles, limestones, sandstones, and granites—but as yet no regularly-worked quarries. Most of the stone work is done by the Mormon church for its own purposes, and the bodies of rock are mostly public property and free to all.

The granite in Little Cottonwood cañon, used for the new temple in Salt Lake City, is taken from large bowlders which have rolled down from each side of the cañon, and are split up and loaded upon the cars. When the supply gets short, more are rolled down to a convenient place for working. The stone is a very handsome gray, and does not rust on exposure, but there are large, almost black, knots called "nigger-heads", through the bowlders, and care has not been taken to have these come on the inside of the walls of the temple, thus marring what would otherwise be a very handsome building. The supply is unlimited, for when all the bowlders are used the solid ledge may be taken; the formation extends about 3 miles up the cañon on each side. At Red Butte, near Salt Lake City, in the foot-hills, is a red Triassic sandstone, which may be had in several different shades. It has been used for the walls of several buildings, the piers of the old Mormon tabernacle, and for the foundations of many buildings. It is easily obtained, as it lies on the crest and sides of quite steep mountains and can be quarried and rolled down into the cañon below. The supply is so great that there will be no need of deep working for many years. The United States government has used about 7,000 cubic yards of this stone in the construction of the officers' quarters, barracks, storehouses, etc., at camp Douglas. The buildings made of this rock are all of rubble work. A few sample grave-stones have been cut from it, and blocks of the same are used for bases to monuments made of other stone. As all help themselves as they wish, I was unable to get any idea of the amount used each year or the expense of quarrying per ton or per yard.

In Echo cañon, near Croydon, there is a quarry of red sandstone similar to the Red Butte, and probably of the same age, owned by the Union Pacific Railroad Company, and is worked by it for stone to put in bridge piers all along the road. It is considered very good for this purpose, as it does not shake to pieces with the jar of the trains. The company has allowed other parties to take stone for use in the vicinity and at Ogden, but the amount used in that way is small.

From 80 to 150 miles south of Great Salt lake, marble specimens have been found, and also the rock in place, though not of a very good quality, owing to the beds being so twisted and shattered that it is impossible to obtain clear pieces of any size. Payson and San Francisco are the localities where most of the specimens have been obtained.

At Manti, in the Sanpete valley, the Mormons have built a temple of oolitic limestone quarried on the ground. It has a very warm, rich, light brown color, cuts very easily, and yet holds its surface well.

At Ogden the Episcopal church is built of a fossiliferous limestone. I was unable to get samples, as there is no regular work done.

The state of Nevada has quarried some stone in the state-prison grounds at Cañon City by convict labor. The stone is of very coarse sand, and contains fossils of both mollusks and vertebrate animals; also the tracks of some animal with three toes, like a bird, very plain in the surface of the stone which forms the floor of the prison-yard. The tracks are 11 inches long from heel to toe, and are 22 inches apart. The United States mint at Carson, the city hall and county buildings, are all built of this stone, and some was taken to Reno to form a portion of the walls of the state prison. The Carson sandstone is not fit for steps, floors, or any place where there is much wear, as it is coarse-grained and soft, and in such positions has to be replaced often. It also absorbs a large quantity of water, making it unfit for foundations or places where it is likely to be exposed to moisture.

At Virginia City a volcanic rock is used for engine beds at the hoisting-works, and in other places where heavy solid foundations are required. The rock will not take a polish, but makes fine rubble work or stone face. It is quite easily quarried, and when freshly taken out cuts well and grows harder on exposure to the weather. There

is no regularly-worked quarry. Granite is also plentiful in the vicinity of Virginia City, but it is not much used owing to cost of working and transportation. A slab is being cut for the Washington monument. The stone is very heavy and of the best quality, but there is no market to encourage any one to open a quarry. The main part of the walls of the old state prison at Reno is of andesite, taken from a large body of this rock which lies about 2 miles north of the city, very easy of access. The rock forms the top of two low hills, which can be connected very easily by a side-track with the narrow-gauge railroad now building from Reno to Oregon. Reno has a few buildings, such as storehouses, built of it.

The building-stone resources of California are immense in both quantity and quality. The granite quarries of Penryn, Pino, and Rocklin are worked extensively and with system. All the granite used in Sacramento and San Francisco, except a little from New England, comes from these quarries.

Around the northern end of the bay of San Francisco, at Napa, Petaluma, Bridgeport, etc., are immense beds of basalt of several different qualities available for the construction of buildings in the future, but now only used for paving stone in San Francisco, Sacramento, and neighboring cities. A few small buildings have been put up in the vicinity of the quarries. Rhyolite is found near Mokelumne Hill in Calaveras county, of several different colors. It is used so far only in the immediate neighborhood; none has been shipped. Lake and Plumas counties each has many varieties of volcanic rocks, but they have not been sufficiently investigated to determine their value as material for construction. On account of want of means of transportation, it will probably be some time before it is used except locally.

The sandstones are also well represented, both in color and texture, all around the bay of San Francisco. At Armory point, just east of Benicia, the United States government has built a large arsenal of light brown sandstone quarried on the spot. This is all that has been used of it, though the color is handsome and the stone is very durable. Angel island, in the bay of San Francisco, now government property, has furnished a bluish sandstone which was used for the Bank of California building; and as far as I can learn, that is all of any account.

Near Alameda, Livermore, Haywards, and a number of other small places, quarrying has been carried on in a very small way in sandstones of various shades of light brown and blue, mostly for the San Francisco market. At San José, near the southern end of the bay, is a quarry of light brown sandstone of several degrees of coarseness, unlimited in extent, and of very even color. The quarry has only lately been opened, and is now used in the trimmings of the new city hall in San Francisco, and for foundation and trimmings of the State Normal School building, San José, and that is all. It is almost pure silica, and stands fire so well that it is used for lining blast-furnaces and for cupolas, forges, etc.; it cuts very easily, when first quarried, into either ornamental, statuary, or faced stone, and grows very hard on exposure to the weather.

California marbles are so bent and fractured by upheavals that it is hard to get pieces of any size without cracks and cavities.

Thousands of dollars have been spent at Colfax in an attempt to open a deposit of drab marble and get it into market, but the parties failed; some of the material was used for mantels, fireplaces, floor-tiles, etc., but the quantity was small and the stone not much liked, so no work has been done for some years.

The so-called "California onyx" is the most beautiful of the marbles, and a small quantity was found at Suisun. This has now all been worked out. Kessler Brothers own another body of it near San Luis Obispo, and are now doing some very handsome work, such as counters for stores, mantels, fireplaces, vases, table-tops, etc. The quarry has not been opened long, and being far from market little has been used, and the quarry is not regularly worked. The owners are going to try and introduce it into the eastern cities.

In Kern county there are marbles of many shades, but all are more or less broken and shattered, making them very hard to work. At Indian Diggings, Eldorado county, a marble has been quarried with almost white ground and blue streaks running through it, used a little for grave-stones, but not much liked, and is not now quarried.

Arizona and New Mexico at the present time use very little stone for building purposes; the climate does not require it, and "adobe" is much cheaper. The Pueblo Indians once used cut stone in the construction of their dwellings, which are now in good preservation in many places.